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Multimedia-Enhanced Developmental Mathematics for Postsecondary Culturally Diverse Students

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Multimedia-Enhanced Developmental Mathematics for Postsecondary Culturally Diverse Students

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Dedication

To Jesus Christ, the author and finisher of my faith.

To God the Father, who told me this would be done in 2015.

To the Holy Spirit, who worked inside of me to bring this to completion.

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Multimedia-Enhanced Developmental Mathematics for Postsecondary Culturally Diverse Students

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Students who are not ready for college must take developmental courses, predominately in math more than reading or writing, because of the need to pass high school algebra as a prerequisite to gain entrance to college. Students who take developmental courses are predominately from minority ethnic backgrounds or from low-income families. These students often have documented learning disabilities (LD) or have been overlooked by the education system. The use of multimedia in the classroom can offer these students various methods for learning, as well as individualized instruction.

The present study compares a multimedia-enhanced (MME) developmental mathematics course that has a mandatory attendance requirement to a course that teaches the same curriculum in a lecture-based format. A mixed-methods comparative analysis pretest posttest quasi-experimental design was used to compare student performance on a posttest and final exam between students taught in the MME section and students taught in the lecture-based section. A course survey was conducted to compare student satisfaction between the two conditions. Interviews were conducted to gather students' perceptions of the barriers and facilitators to learning in both conditions, as well as to determine students' past experiences with mathematics learning and their dispositions towards mathematics learning in general.

The results showed that there were no statistically significant differences in student performance on the posttest and final exam between the students taught in the MME section and the students taught in the lecture-based section. There was no statistically significant difference in student satisfaction between the two sections. The barriers included the short amount of time for the summer course and lack of technology skills. The facilitators included: (a) helpful instructor, (b) supplementary videos provided by faculty member, (c) collaboration with peers, (d) examples in the software showing how to work the problems, (e) step-by-step instructions, (f) portability of the course, (g) ability to print from the lab, (h) working in the lab, (i) working at own pace, (j) access to the textbook online, and (k) opportunities for practice. These results are discussed in further detail and implications for practice and further research are also considered.

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Chapter 1: Introduction to Research

Many students are not ready for college and must take developmental courses (Aud et al., 2013). These students are disproportionately from African American and Hispanic ethnicities (Aud et al., 2013; Bahr, 2010a). Many of the students taking developmental courses also have learning disabilities (LD; Kortering, Braziel, & McClannon, 2010; NCES, 2014; Schnapp, 1995). Students who need developmental courses are more likely to need developmental mathematics than reading or writing courses (Le, Rogers, & Santos, 2011). The use of multimedia can help students who are struggling because it can address the needs of learners in various ways (Gaudelli, 2006; Simonson & Schlosser, 2009; Spradlin & Ackerman, 2010). This chapter begins with a discussion of the conceptual framework for this study (see Figure 1.1). The framework is a tool that will be used to organize the main ideas of the study. This chapter is then divided into the following sections: (1) College Readiness and Sociocultural Considerations, (2) Developmental Mathematics, and (3) Multimedia-enhanced (MME) Instruction.

CONCEPTUAL FRAMEWORK

The conceptual framework consists of two branches: factors relating to students who take developmental mathematics at Houston Community College and factors relating to a MME developmental mathematics course. The student factors include sociocultural considerations and LD and mathematics difficulties. Sociocultural considerations are drawn from the literature on multicultural education and are applicable to this study because of the high proportion of Hispanic and African American students at Houston Community College. An understanding of mathematics LD and difficulties are critical for this study since many students who take developmental mathematics courses have LD and mathematics difficulties (Kortering et al., 2010; NCES, 2014; Schnapp, 1995).

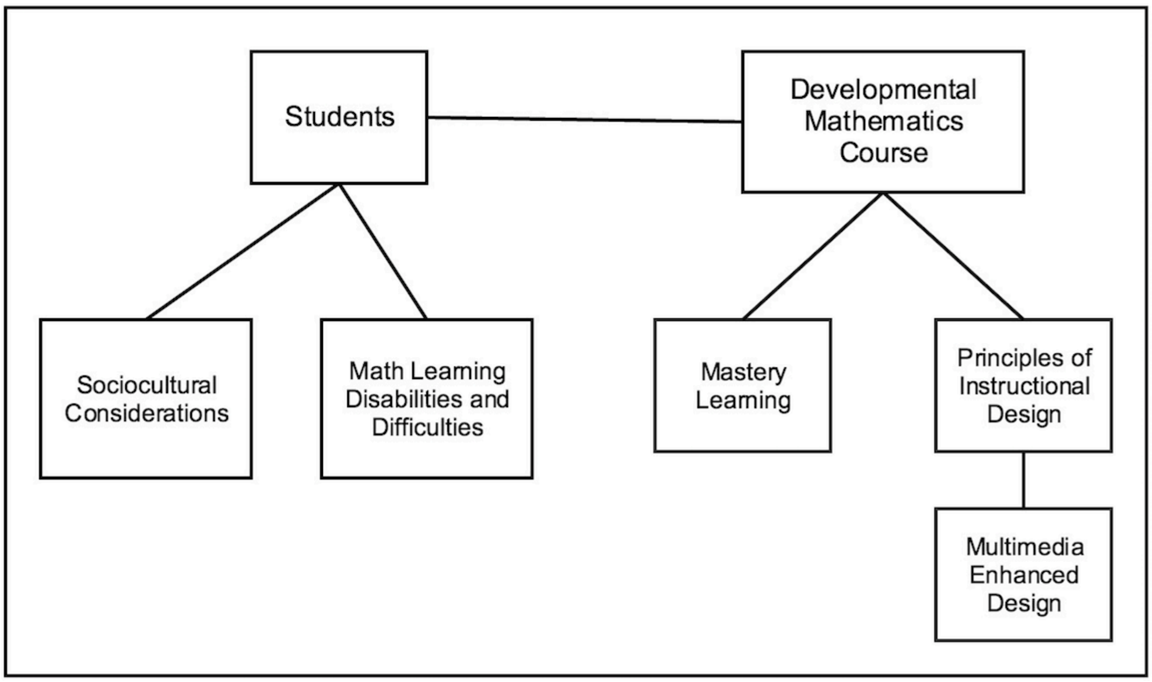

Figure 1.1 Conceptual Framework

The first branch of the conceptual framework centers on students. It is important to understand students' need for developmental mathematics and the critical state students are in when they are enrolled in a developmental mathematics course: success is far from guaranteed. Mastery learning is important to this discussion because the developmental mathematics course is built on a foundation of mastery learning.

The second branch of the conceptual framework is factors related to a MME developmental mathematics course, and includes an understanding of multimedia-enhanced course design, developmental mathematics, and mastery learning. An understanding of multimedia-enhanced instruction includes knowledge about the principles of instructional design for a multimedia-enhanced course

College Readiness and Sociocultural Considerations

Around 40% of traditional college students enroll in one or more remedial courses to prepare for college-level coursework (Barnett et al., 2012; Brothen & Wambach, 2004; Callan, 2008; Le et al., 2011). One of the reasons for this is the disjointedness of high school graduation standards and college academic expectations (Barnett et al., 2012). Currently, the pathway from high school to college does not reliably lead to a college degree (Barnett et al., 2012). One of the reasons for this is that earning higher grades in high school is not enough to ensure that students will be successful in college (ACT, 2013). The graduation standards of high schools are misaligned with the academic expectations of postsecondary institutions (Barnett et al., 2012).

To be accepted at a college or university in the State of Texas, a student must pass the State of Texas Assessments of Academic Readiness (STAAR) in high school or perform satisfactorily according to each university's requirements, on a college entrance examination such as the Scholastic Aptitude (SAT) or American College Testing (ACT). Students who do not achieve at least one of these requirements must fulfill a program of remediation by enrolling in non-credit developmental courses in either language arts or mathematics, depending on their score on the STAAR, SAT, or ACT (Bump, 2004). The terms “remedial” and “developmental” are often used interchangeably. For the purposes of this study, courses that have the purpose of promoting student scholastic preparedness for university-level mathematics courses will be referred to as developmental mathematics courses because this is the description used by the majority of community colleges (Okimoto, 2012).

Students who are from underrepresented ethnic and cultural groups and students from lower income populations are less likely to be prepared for college (ACT, 2013). A student’s financial situation is highly related to persistence, graduation, and time to degree (Camara, 2013). Even though there have been increases in enrollment rates among all ethnic and income groups, participation gaps between wealthy students and those from less advantaged backgrounds have continued (Camara, 2013). Additionally, students from low socioeconomic groups have lower rates of college attendance compared to their peers from higher socioeconomic groups. In addition, gaps in degree completion are greater than gaps in enrollment because lower-income students who are able to surmount the financial difficulties to enter college are less likely to attain degrees (Camara, 2013). This is due in part to the need students from lower socioeconomic status have to work while enrolled in college. Financial difficulty is a significant barrier to postsecondary education and degree completion and can influence a student’s living conditions, wellbeing and, eventually, academic persistence and success (Kane, Beals, Valeau & Johnson, 2004).

According to King (2002), students who are employed 14 hours per week or more are much more likely to withdraw from college than those who are employed fewer hours per week. Employment can help reduce economic hardship, but it can also generate stresses on students that delay their educational success (Kane et al., 2004).

According to the National Center for Educational Statistics (Aud et al., 2013), 78.2% of ninth graders graduate from high school. That percentage is lower for African American and Hispanic students, at 66% and 71%, respectively. In 2011, 26% of student graduates immediately enrolled in a two-year college, and 42% enrolled in a four-year college (Aud et al., 2013). For students who entered a four-year college, 59% graduated within 6 years; but only 31% of students who entered a two-year college gained their credential within 3 years. For students to graduate from a four-year college in 6 years or for students to gain a credential from a two-year college in 3 years is 150 percent of the normal time required to do so.

Students with LD may not have the independence that they need to adapt to college, and do not know how to pursue assistance and services (Kortering et al. 2010; Schnapp, 1995). According to Schnapp (1995), “They do not know how to self-identify, to seek out appropriate support services, or to identify suitable accommodations or modifications” (p. 27). Students with mathematics disabilities (MD), or “persistent difficulty in the learning and mastery of number concepts,” (Geary, 2006, p. 1), can have trouble mastering basic arithmetic concepts (Wu, Willcutt, Escovar, & Menon, 2014) and struggle with the following: understanding number concept; counting; abstract concepts of time, temperature, speed, and directions; estimating; solving word problems. Many students with MD have lower than expected scores on mathematics achievement tests (Watson & Gable, 2013). These struggles likely persist “later in their academic career as they encounter more advanced mathematical concepts,” (Wu et al., 2014, p. 503).

Because of their struggles with number concepts, with abstract concepts, with estimating, and with solving word problems, students with MD may be likely candidates for a developmental mathematics course at a community college. Developmental education, which houses developmental mathematics, is defined as courses that "bridge the gap between secondary and higher education for students who are not prepared for college-level work" (Kisker & Outcalt, 2005). It is also defined as courses and services offered to assist underprepared college students achieve their educational goals (Boylan & Bonham, 2007). Developmental education may also incorporate an array of support services, such as counseling, advising, tutoring, workshops, learning laboratories, and assessment (Boylan & Bonham, 2007). Various institutions combine diverse components in their developmental educational programs.

The community college is an entry point for many students from underserved and low-income populations, as affordability is a major factor (Le et al., 2011; National Center for Public Policy and Higher Education, 2011). Students who enroll in community colleges or two-year programs are more likely to be from families with low incomes, the first in their families to attend college, and members of underrepresented and traditionally underserved ethnic groups (Aud et al., 2013, Bahr, 2010a; Gandara, Alvarado, Driscoll, Orfield, & University of California, 2012; National Center for Public Policy and Higher Education, 2011). More students from low-income families (with incomes of less than

$25,000 per year) attend community colleges as their first college after high school than do students from high income families (Callan, 2008; Gandara et al., 2012; National Center for Public Policy and Higher Education, 2011).

Bahr (2010a) stated that, “remedial coursework represents a lifeline in the ascent to financial and social-structural stability for individuals who face significant deficiencies in foundational subjects” (p. 1). Developmental education is “intended to restore opportunity to those who otherwise may be relegated to meager wages, poor working conditions, and other consequences of socioeconomic marginalization” (Bahr, 2008, p. 422).

DEVELOPMENTAL MATHEMATICS

The students who must take developmental courses are most likely to need significant help with mathematics (Le et al., 2011). According to Parsad, Lewis, and Greene (2003), 42% of first-year students at two-year colleges are enrolled in a developmental course, and more are enrolled in developmental mathematics courses (35%) than in reading (20%) or writing (23%). A primary consideration with developmental courses is that too few students remediate successfully or perform satisfactorily in their courses, and those who are successful are disproportionately the ones who require the least assistance (Bahr, 2008). Those students who need the most assistance are the ones most unlikely to get the help that they need.

Those who take developmental mathematics courses have the lowest outcomes in terms of completing the developmental education sequence and then completing one or more credit-bearing courses, compared to students enrolled in developmental reading or developmental English courses (Le et al., 2011). That is, the area of developmental education that has the most students with the greatest needs also has the lowest results. Furthermore, rates of successful academic outcomes differ significantly by ethnicity; African American and Hispanic students experience the lowest rates of successful remediation in mathematics courses and are also overrepresented in developmental mathematics (Bahr, 2010a).

When students withdraw from a developmental mathematics course, they are quite often automatically withdrawn from their other classes. Passing a standardized test such as the ACT or SAT is a prerequisite for college level courses, and failure in the mathematics courses, which prepare students for the test, generally discourages and frustrates the students such that they eventually withdraw from college (Brothen & Wambach, 2004; Bump, 2004). This cycle needs to be reversed so that students can encounter progress and achievement in the first year of college. One of the ways educators are aiming to reverse this is by incorporating the use of multimedia into the developmental mathematics curriculum (Rutschow & Schneider, 2014).

MULTIMEDIA

Today, technology plays a critical role in developmental mathematics, with online homework submission and MME instruction, which includes software curriculum packages, whole courses offered online, and streaming video tutorials (Boylan & Bonham, 2014; Rutschow & Schneider, 2014). Online learning and technology provide teachers with a new medium to express knowledge and improve student learning. In an online course or a computer lab setting, students can adopt a more dynamic role in their learning (Sorensen & Baylen, 2009). Teachers in the past did not have any choice but to engage students by using chalk and a blackboard, or more recently, dry-erase markers and overhead projectors. With technology, it is possible for students to have a more hands-on approach and interaction, as compared to the more passive role students perform in some traditional classrooms.

As technology advances, online courses are being used to supplement traditional learning in schools. The use of coursework on the Internet to supplement face-to-face education is widely employed for both graduate and undergraduate courses at an escalating number of universities across the nation (Bullock, Gable, & Mohr, 2008; Hughes & Hagie, 2005; Wang & Wang, 2009). The Internet allows users to access the course materials at times and locations of their choice (Hoffman, 2002). An instructor can use the Internet in conjunction with computer-assisted instruction, that is software that is not reliant on the internet to function, to take advantage of technologies to engage students in the learning process. Students who are actively involved in learning will remember more and remember it longer than when they are engaged in passive listening activities (Sorensen & Baylen, 2009). Online instruction can also offer immediate feedback and assessment and give students frequent opportunities to demonstrate knowledge as well as receive suggestions for improvement.

Though computers and the Internet can offer all these advantages, there are still several issues that need to be addressed. One of the most noted challenges of online learning is the lack of meaningful interaction between students and teachers and between students and other students (Bullock et al., 2008).

Another challenge students may experience in an online learning environment is technical difficulties. In an online course, students are required to have access to a computer and proficiency in navigating the course website. If there are problems with the course website, a web technician must be contacted to remedy the problems. In a multimedia enhanced course, students still need to have access to the computer if they want to work on the course modules away from campus, or outside of the computer lab setting. However, because attendance is required for the courses in this study, students have the benefit of having the instructor available, who is trained to help students access the course modules and troubleshoot the issues that may occur. There are also technical personnel present at the college who would not be available to the students if they were enrolled in a fully online course. Because the course is held in person, yet is also online, students are able to work at their own pace, complete work from home, view their progress at any time, receive immediate feedback on problems, and have ongoing assessment. They are also able to have interaction with the content, other students, and the instructor.

Multimedia-enhanced instruction is a term that includes “online courses (distance learning) and/or computer-mediated instruction where the delivery format requires a computer and a packaged software product to deliver the content of the course" (Zavarella & Ignash, 2009, p. 2). There are many different software packages that faculty use for developmental mathematics programs. Currently, the most widely used are MyMathLab and ALEKS (Dass, 2012; Kodippili & Senaratne, 2008; Okimoto, 2012; Siadat, Peterson, Oseledets, Wang & Zhang, 2012; Potocka, 2010; Stillson and Alsup, 2003; Taylor, 2008; Trenholm, 2009). Blackboard and WebCT are often used for quizzes, tests, and grading (Boggs, Shore & Shore, 2004). Blackboard Cartridges and Blackboard Random Blocks are programs that can be used to create multiple versions of tests for students at varying levels and at different periods of time (Boggs et al., 2004). Students are able to take tests on their own, individually, and at a time that is convenient for them. Any of these services provide automatic grading and offer students immediate feedback on their tests. Tests can be randomized, allowing for students to have different questions on the same level, which can eliminate cheating (Bump, 2004). Students are able to progress through their course objectives faster. CBI can offer students an opportunity to be dynamically engaged in the learning process, whereas traditional lecture alone allows students to be passively involved (Spradlin & Ackerman, 2010).

According to Simonson and Schlosser (2009), it is important to make four media available to students: print, audio, video, and computers. In Figure 1.2, these can be seen in the boxes, with the audio and video combined. Students taking an online course have at least seven needs that must be addressed through the course design: (1) content that is relevant to their needs, (2) clear instructions for what they should do at every phase of the course, (3) a way to address their individual concerns, (4) as much control of the speed of learning as achievable, (5) a way of assessing their progress and receiving feedback from the instructor, (6) materials that are beneficial, dynamic and stimulating, and (7) interaction with content, other students, and the instructor (Simonson & Schlosser, 2009). The following framework will be helpful for understanding the way the four media types are used in this course (See Figure 1.2).

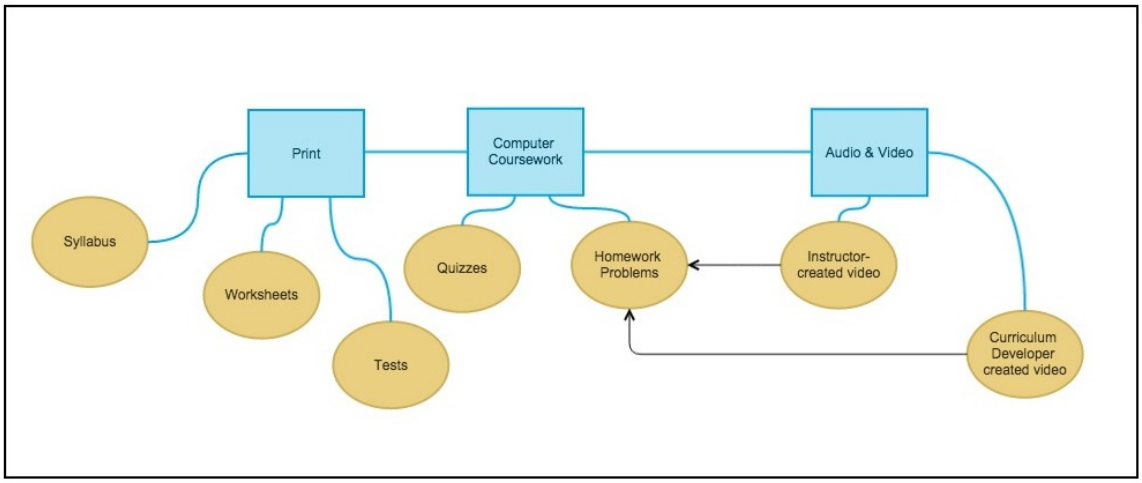

Figure 1.2 Framework of the Multimedia-Enhanced Developmental Mathematics Course

Statement of the Problem

Students who are placed in developmental courses hold a low probability of degree attainment (Brothen & Wambach, 2004). The fact that students who do need developmental courses are more likely to drop out, as compared to those students who do not need developmental courses may be due to the fact that the students who do need developmental courses did not pass their developmental education courses. Further, those students in developmental courses dropped out of college earlier, in comparison to students who did not take any developmental courses (Baxter and Smith, 1998; Brothen & Wambach, 2004; Burley, Butner, and Cejda, 2001; Grimes, 1997; Hoyt, 1999) The students who most likely require the developmental courses hold the poorest likelihood of successful remediation (Bahr, 2010b).

Studies have examined passing rates in developmental mathematics courses (Gerlaugh, Thompson, Boylan, & Davis, 2007; Okimoto, 2012) and student retention rates (Fike & Fike, 2008). Another study compared student grade averages between a course section that used MyMathLab as homework and a traditional course that did not use the online program for homework (Kodippili & Senaratne, 2008). Potocka (2010) compared the final exam grades of a completely online section of students using MyMathLab as the sole instruction (no instructor was present) with a traditional lecture-based course. No studies, to my knowledge, have compared student averages between a multimedia enhanced course that uses MyMathLab with the two major benefits of supporting video instruction and an instructor always present to help, and a traditional lecture-based course, which teaches the same curriculum and uses the same assessment, without the use of computers to deliver instruction. It is also important to gather data concerning the students' perceptions of the barriers and facilitators to their learning in a multimedia enhanced course.

RESEARCH QUESTIONS

The first purpose of this study is to perform a comparative analysis of two modes of instruction on introductory algebra in a developmental mathematics course. The second purpose of this study is to discover what the students in the MME course perceive to be helpful, or to facilitate their learning in the course, and to also discover what they perceive to be barriers to their learning in the course. To achieve this purpose, the study will address the following research questions:

1. Is there a statistically significant difference in the performance on an algebra course final exam between students taught in a multimedia-enhanced course and students taught with lecture-based instruction in an introductory algebra course with pretest score as the covariate?

2. Is there a statistically significant difference in posttest scores between students taught in a multimedia-enhanced course and students taught with lecture-based instruction in an introductory algebra course with pretest score as the covariate?

3. Is there a significant difference in levels of student satisfaction between the multimedia-enhanced section and the traditional lecture-based section?

4. What are the students' perceptions of the barriers and facilitators to their learning in the multimedia-enhanced course and the lecture-based course?

5. What are the students' past experiences with mathematics and dispositions towards mathematics learning in general in both the multimedia-enhanced course and the lecture-based course?

Chapter 2: Literature Review

The purpose of this study is to compare a multimedia-enhanced developmental mathematics course to a traditional lecture-based course. This chapter presents a review of the related literature, including an overview of developmental education and developmental mathematics courses. This chapter will also include a section on student factors, including multicultural issues and the needs of students with learning disabilities (LD). Multimedia-enhanced instruction is described in this chapter, and highlighted as a way to address those concerns. Mastery learning in the multimedia-enhanced classroom, via multimedia-enhanced (MME) instruction is discussed here as a framework for presenting the curriculum.

DEVELOPMENTAL EDUCATION

Developmental mathematics courses prepare and qualify students for college level mathematics courses such as college algebra, calculus, statistics, finite mathematics, and probability (Kane et al., 2004; Kisker & Outcalt, 2005). Developmental education is defined as courses and services offered to assist underprepared college students achieve their educational goals (Boylan & Bonham, 2007). Developmental education may also incorporate an array of support services, such as counseling, advising, tutoring, workshops, and learning laboratories (Boylan & Bonham, 2007). Various institutions combine diverse components in their developmental educational programs.

Developmental courses are offered at almost all post-secondary institutions in America (Dass, 2012). Developmental mathematics is the largest branch of developmental education. More students are enrolled in developmental mathematics courses than in reading or writing (Parsad et al., 2003), and technology functions as a large part in the delivery of that instruction (Boggs et al., 2004; Siadat et al., 2012; Taylor, 2008; Zavarella & Ignash, 2009).

In summary, developmental education is comprised of courses and other supporting services that prepare post-secondary students to undertake college-level coursework. Reading, writing, and mathematics are the most prevalent subjects in this branch of education.

STUDENT FACTORS

Sociocultural Factors

Many students attend community colleges for developmental education courses, as community colleges serve 44% of the total undergraduate college population, with the vast majority of those students classified as either minority students, first generation college students, or both (American Association of Community Colleges, 2012). Fry (2011) confirms this trend:

> Much of the growth in college enrollment among young Hispanics has been at community colleges. Of all young Hispanics who were attending college last October, some 46% were at a two-year college and 54% were at a four-year college. By contrast, among young white college students, 73% were enrolled in a

> four-year college, as were 78% of young Asian college students and 63% of young black college students. (p. 5)

Epper and Baker (2009) stated that, “students who test into remedial math coursework are disproportionately minority and disproportionately first generation, two characteristics of at-risk students” (p. 3). African American and Hispanic students in developmental education courses experience the lowest rates of successful remediation and are overrepresented in developmental mathematics courses (Aud et al., 2013; Bahr, 2010). While 57% of Asian Americans and 44% of White Americans have completed an Associate’s or Bachelor’s degree, only 21% of Hispanic and 30 percent of African Americans have done the same (Santiago & Soliz, 2012).

The achievement gap between White students and culturally and linguistically diverse students is well documented (Duncan & Murnane, 2011; Guskey, 2010; Milner, 2013; Reardon, 2013; Riegle-Crumb & Grodsky, 2010). Barnes and Slate (2014) reported that for the 2008-2009 academic year, college-readiness rates in reading varied from a low of 38.41% for Black students to a high of 62.71% for White students. During the 2006-2007, 2007-2008, and 2008-2009 academic school years, in Texas, White students exhibited higher college-readiness rates than Black students and Hispanic students as measured by the Texas Education Agency college readiness indicator data. Furthermore, Hispanic students outperformed Black students.

The achievement gap is demonstrated in income as well (Guskey, 2010). Kane et al. (2004) describe the effects of financial hardship on student success, one of which is that it is a significant barrier to postsecondary education and degree attainment. Financial hardship can also impact a college student’s conditions for life, including shelter, clothing, health, nutrition and, ultimately, academic persistence and success. Having a job may help decrease economic hardship, but it can create stresses on students that hinder their educational achievement (Kane et al., 2004).

Taylor (2008) described students in developmental mathematics courses as being first generation college students and having limited or no support from home. They may have experiences that include only minimal academic college success, and have weak concepts of self. Self-efficacy relates to students' beliefs about whether they can effectively perform the requisite actions or behaviors necessary to produce the outcome (Eccles & Wigfield, 2002). Bandura (1997) proposed that individuals' efficacy expectations determine their goal setting, activity choice, inclination to expend effort, and persistence. Students in developmental mathematics courses often have low efficacy expectations, exhibited through negative attitudes and anxiety issues (Spradlin & Ackerman, 2010; Taylor, 2008). Therefore, some students may choose to enroll in a multimedia-enhanced course because they might consider online learning to be easy or less time-consuming than traditional course sections (Zavarella & Ignash, 2009). Also, students in developmental courses may not understand their individual learning needs. Zavarella and Ignash (2009) state that "the importance of receiving tutoring for students enrolled in CBI [computer-based instruction] for developmental courses should be communicated early and often throughout the semester" (Zavarella & Ignash, 2009, p. 10).

Students with LD

Many students enrolled in developmental education courses have LD and mathematics difficulties (Kortering et al., 2010; NCES, 2014; Schnapp, 1995). During their college years, students with LD face a special set of challenges that their non-disabled peers do not. Students with disabilities are less likely to enroll in college than their counterparts without disabilities (National Center for Education Statistics, 2014). For those who do enroll, many do not report their disability (Krupnick, 2014; Street et al., 2012). Failure to report a disability creates a lack of access to accommodations and modifications that are necessary for students to succeed in their coursework (Street et al., 2012). Durodoye, Combes, and Bryant (2004) found that many postsecondary African American students with disabilities do not reveal their disability or pursue appropriate evaluation to obtain accommodations. The National Center for Educational Statistics (2011) reported that only 28% of college students who were reported by their high schools as having a disability disclosed a disability to their postsecondary schools. Further, only 19% of those students who were identified with a disability in high school were reported to have received any accommodations or supports because of their disability from their postsecondary institutions (Newman et al., 2011). This can be attributed to several different factors. Banks (2014) reported that students' limited awareness of their learning characteristics had an impact on their willingness to seek disability support services. Students may not be aware of their best ways of learning, and what they need to help them to succeed in their learning environment. Banks (2014) also found that it was primarily external social elements that caused the barriers facing

African American students with disabilities, rather than the students' academic limitations. Students may be concerned with "faculty members' attitudes toward race and disability status" (Banks, 2014, p. 29).

After they transition from high school to college, students with disabilities are responsible for requesting and acquiring those accommodations and supports (Eckes & Ochoa, 2005; Newman et al., 2011). This is an important difference, because from elementary through high school the institution is responsible for identifying students with disabilities and providing the appropriate support. Some students may be intimidated by perceived attitude of faculty members, and therefore not ask for what they need. However, when students do receive appropriate accommodations, it has been shown to positively impact academic success for students with disabilities (Newman et al., 2011). NCES (2011) reported that the most widely used accommodations and supports included the following: additional time to complete tests; tests administered in a different than usual setting; computer software designed for students with disabilities; tutors; note-takers, readers, or in-class aides; learning strategies, study skills, or behavior management supports; modified assignments; extended deadlines; written materials; and large print. Many of the technological accommodations students need are readily available and provided in a multimedia-enhanced classroom.

In summary, the population of students in developmental education is significantly different from the higher education population as a whole. These students are disproportionately minority, low income, have a LD, and first-generation college students. In addition, the students with LD often do not seek out available accommodations and support (which are known to have a positive impact on academic success).

Multimedia-enhanced Instruction

Technology can be used to address the needs of students with LD, because several of the most widely used accommodations are immediately available in multimedia-enhanced classrooms that use computer based instruction: audio and written materials, large print, extra time to complete quizzes, and computer software (Kodippili & Senaratne, 2008; Taylor, 2008; Trenholm, 2009; Zavarella & Ignash, 2009). Technology presently performs a critical role in developmental mathematics, with calculators, graphing calculators, online homework submission, and computer-based instruction, which includes software curriculum packages, whole courses offered online, and streaming video tutorials (Boggs et al., 2004; Siadat et al., 2012; Taylor, 2008; Zavarella & Ignash, 2009).

Instructional Design

In a multimedia-enhanced classroom, the software curriculum does not dictate the overall design of the course, nor does it guarantee effective instruction. Simonson, Smaldino, and Zvacek (2015) stated that the key to effective instruction is the concept of design. The authors quoted Seels and Richey (1994) in their definition of design as "the process of specifying conditions for learning," while, "the purpose of design is to create strategies and production at the macro level, such as programs and curricula, and at the micro level, such as lessons and modules" (p.30).

Reigeluth (2013) described the discipline of instructional design as functioning as "a body of knowledge that prescribes instructional actions to optimize desired instructional outcomes, such as achievement and affect," (p. 5). When designing instruction, all aspects of the learning environment should be considered, such as the instructors, learners, material, and the technology (Simonson et al., 2015). All of these components of the learning environment interact with each other to construct the type of experience fundamental to student learning.

Seven principles of instructional design

Nearly three decades ago, Chickering and Gamson (1987) published the "Seven Principles of Good Practice in Undergraduate Education" which specify some fundamental elements that are necessary in designing effective learning environments. These seven principles are: (1) encourage student-faculty contact, (2) encourage cooperation among students, (3) encourage active learning, (4) give prompt feedback, (5) emphasize time on task, (6) communicate high expectations, and (7) respect diverse talents and ways of learning. These principles are foundational in education and are cited in many current books and journals (Arum & Roksa, 2011; Astin, 2012; Barkley, Cross, & Major, 2014; Kuh, Kinzie, Schuh, & Whitt, 2011; Meyer, 2014; Moore, 2013; Walvoord & Anderson, 2011).

Sorensen and Baylen (2009) list these principles as significant considerations when designing instruction in technology-based environments, and give suggestions for applying these principles to a web-based setting. First, student-faculty communication can be encouraged through the use of email and video conferencing. Email provides asynchronous communication, while video conferencing provides synchronous communication.

Following the first principle, in a technology-based environment, students can be encouraged to cooperate together in chat rooms and online group discussions. Instructors can help to develop and strengthen a sense of community by having students write introductory emails to the instructor and other students enrolled in the course. This is beneficial for students who are shy or are second language learners as they are able to take more time to form their introductions. Instructors can also assign students to teams or pairs and allow for group work and collaboration on group assignments (Sorensen & Baylen, 2009).

The use of active learning techniques is the third principle and can be applied in a multimedia-enhanced classroom. These techniques can be hands-on, experiential, participative, or inquiry-based (Sorensen & Baylen, 2009). Technology can provide students with animations, graphing technologies, problem or project-based learning, games, and structured online discussions.

Technology is also useful for giving prompt feedback, which is the fourth principle. Courseware, or course management systems (CMS), can provide the mechanism for confirmation of receipt of assignments, and also assist the instructor in giving immediate feedback. CMS are a basic component of multimedia-enhanced instruction (Simonson et al., 2015), and are “software systems designed to assist in the management of educational courses for students, especially by helping teachers and learners with course administration…in an accessible online environment" (Simonson, 2007, p. vii). CMS provide course management components such as syllabi, course calendar, announcements, assignment instructions and submission spaces, learning objectives, student rosters, and glossaries (Koszalka & Ganesan, 2004; Simonson et al., 2015).

The employment of CMS also relates to the fifth principle, which is time on task. Technology can encourage students to manage their time and document their time on task. The use of CMS can provide instructors with frameworks for assignments and quizzes and can also keep students focused by giving specific beginning and end dates for students to take quizzes and complete assignments in a timely manner (Sorensen & Baylen, 2009). The following are examples of how CMS help to keep students on task: online calendars to point out due dates to students, sending email reminders, posting reminders for assignments, checkpoints to determine whether students are satisfactorily moving through the materials, course mapping so that students can see where they are in terms of the course, arranging the course in individual units, and establishing protocol for the completion of units (Sorensen and Baylen, 2009).

Communicating high expectations is the sixth principle. There are several ways this can be accomplished in a multimedia-enhanced course. The instructor can direct the students to a page or set of pages describing the course policies and performance expectations. Also, the assignment information and instructions with links to resources can be easily accessed via the computer. Instructors can also provide grading rubrics that demonstrate acceptable performance and supplementary online study guides. In general, technology can provide a space for giving detailed information about the course.

Finally, the instructor should provide diverse ways of learning; and this can be accomplished through the use of visuals, print, virtual experiences, opportunities for self-reflection and self-evaluation, collaboration and group learning, and giving students options within the structure of the course. Taking into consideration the diverse learning needs of the individuals in the classroom is an important aspect of instructional design.

Learner considerations

An important aspect of designing instruction is to take into account the learners' needs. Simonson et al. (2015) give several factors to consider. The first step is to consider the sociocultural background of the students. This includes disability type; family factors such as income, immigration status, and language dominance; English language proficiency; race and ethnicity; and employment (Trainor, 2008).

Secondly, it is imperative is to understand learner characteristics (Simonson et al., 2015). These characteristics include the learner's age, and educational background, as well as the students' level of familiarity with the technology and course delivery system being used. Students have "different backgrounds, strengths and weaknesses, interests, ambitions, senses of responsibility, levels of motivation, and approaches to studying," (Felder & Brent, 2005, p. 57). Gay (2010) called for culturally responsive teaching, a pedagogical paradigm that "teaches to and through their personal and cultural strengths, their intellectual capabilities, and their prior accomplishments" (p. 26), to improve the achievement of underperforming students from diverse cultural groups. Gay (2010) also stated that, “to the extent that teaching builds on these capabilities, academic success will result” (p. 213).

Felder and Brent (2005) explained that how much a student learns is dependent not only on their previous experience but also by the compatibility of the student’s attributes as a learner and the instructor’s teaching approach. Instructors may choose to ask students questions to learn about their needs, backgrounds, and expectations, in attempt to better understand the students in the class (Simonson et al., 2015).

Similarly, the third step is to analyze the general abilities of the class. An investigation of the cognitive abilities of the students gives the instructor a window to observe how students relate to the content (Simonson et al., 2015). Defining the knowledge and skills required to complete the tasks, and also learning about students’ prior knowledge and experience with similar types of cognitive tasks is important to understanding the general abilities of the class.

The fourth step is to help learners understand the context of the learning experience. Morrison, Ross, Kalman, and Kemp (2012) described three types of contexts: orienting context, instructional context, and transfer context. The orienting context is the reason the students are enrolled in the course. For example, in a developmental education course, students may enroll because it is a prerequisite for college algebra. The instructional context has to do with the convenience of the location and time of the course, and whether students have to rearrange their work or personal schedules. It is helpful, for example, for instructors to be cognizant of whether a student has childcare concerns or work-related issues, as "these may impact the manner in which the student interacts with the class," (Simonson et al., 2015, p. 133).

The third context, transfer context, involves the students' use of the knowledge that they gain from the course. Instructors must know how the instruction might apply to the students' lives, in order to make learning meaningful and useful to the students. When instructors understand the transfer context for the students, they may ensure that the transfer of learning can take place, giving the students a way to use the acquired knowledge in their jobs or future courses (Simonson et al., 2015).

Instructional technology and mastery learning

CBI is a specific type of a multimedia-enhanced course, and is a term that includes "online courses (distance learning) and/or computer-mediated instruction where the delivery format requires a computer and a packaged software product to deliver the content of the course" (Zavarella & Ignash, 2009, p. 2). There are many different software packages that faculty use for developmental mathematics programs. Blackboard and WebCT are often used for quizzes, tests, and grading (Boggs et al., 2004). Blackboard Cartridges and Blackboard Random Blocks are programs that can be used to create multiple versions of tests for students at varying levels and at different periods of time (Boggs et al., 2004). Students are able to take tests on their own, individually, and at a time that is convenient for them. Any of these services provide automatic grading and offer students immediate feedback on their tests. Tests can be randomized, allowing for students to have different questions on the same level, which can eliminate cheating. Students are able to progress through their course objectives faster.

Many of the CBI programs reflect a mastery learning oriented design (Boggs et al, 2004; Dass, 2012; Taylor, 2008). MyMathLab, ALEKS, and Hawkes are all three designed for mastery learning. Mastery goals tend to focus more on learning and self-improvement, while performance goals deal more with demonstrating ability or not appearing less capable than others (Harackiewicz, Barron, Pintrich, Elliot, & Thrash, 2002).

What we know of and how we use mastery learning came from Benjamin Bloom's adaptations of individualized instruction and tutoring (Guskey, 2010). Bloom thought that if students could have the necessary time and appropriate learning conditions, they all could achieve mastery of the content (Guskey, 2010). Mastery learning is a form of differentiated instruction that calls for frequent assessment of student progress using concise tests at the end of each unit (Department of Education, 2008). These units are smaller sections of the course material to be taught (Fuchs, Fuchs, & Tindal, 1986). There are usually tests or quizzes once a week, and students may take the quizzes at varying times, according to their own progress through the material. Those who do not reach a mastery level are retaught the content and provided another test or quiz. The mastery level may vary by classroom but is usually around 80% (Department of Education, 2008). The level of difficulty of the tests or quizzes may vary from unit to unit depending on both the difficulty of the topic and the difficulty of the items selected.

Those with scores above the mastery level are provided with enrichment activities (Department of Education, 2008). Mastery Learning is the foundation in many developmental mathematics programs that use computer-assisted instruction (Boggs et al., 2004; Taylor, 2008). Because of the high level of individualization, CBI is positioned to facilitate a Mastery Learning framework.

SUMMARY OF CHAPTER

In summary, multimedia-enhanced instruction can facilitate and enhance the delivery of developmental mathematics courses. In the area of instructional design, it provides many options to robustly address each of the seven principles laid out by Chickering and Gamson (1987). Multimedia-enhanced education can also create opportunities for the instructor to fully understand the learners' needs. Finally, it is also a platform on which an instructor can effectively implement a mastery learning based course design.

Developmental education is defined by the goal of preparing post-secondary students for college-level classes. The students served by developmental education are more likely to be minorities, first generation college students, low income, and learning disabled than the overall population of higher education students. Multimedia-enhanced instruction can conceivably be a valuable tool in delivering courses that effectively help these students progress on to college level mathematics classes.

Chapter 3: Research Method

The purpose of this study was to perform a comparative analysis of two modes of instruction on introductory algebra in a developmental mathematics course. To achieve this purpose, the study addressed the following research questions:

1. Is there a statistically significant difference in the performance on an algebra course final exam between students taught in a multimedia-enhanced course and students taught with lecture-based instruction in an introductory algebra course with pretest score as the covariate?

2. Is there a statistically significant difference in posttest scores between students taught in a multimedia-enhanced course and students taught with lecture-based instruction in an introductory algebra course with pretest score as the covariate?

3. Is there a significant difference in levels of student satisfaction between the multimedia-enhanced section and the traditional lecture-based section?

4. What are the students' perceptions of the barriers and facilitators to their learning in the multimedia-enhanced course and the lecture-based course?

5. What are the students' past experiences with mathematics and dispositions towards mathematics learning in general in both the multimedia-enhanced course and the lecture-based course?

This chapter describes the methodology that was used to answer these research questions. This chapter is divided into the following sections: (1) participants and setting, (2) research design, (3) procedures and treatment, (4) data analysis.

PARTICIPANTS

The population of focus in this study was community college students enrolled at the Houston Community College System – Southeast College for the summer 2015 semester in the introductory developmental mathematics course 0409. According to the Houston Community College System (2014), the total number of students enrolled for the Fall 2013 semester was 69,714. Of this total, 92.6% were 18 years old and older. The ethnic background of the total population was 31% African American, 31.7% Hispanic, 15.2% Caucasian, 9.5% Asian, 0.4% American Indian, 9.2% nonresident alien, and 3.1% unknown. Of these students, 42.4% were male, and 57.6% were female. The average age of these students was 26.5 years old.

The participants in this study were a convenience sample, which is a selection of a group of participants based on accessibility in terms of time and geography (Mertens, 2005; Miles, Huberman & Saldaña, 2014). The treatment group consisted of 11 students enrolled in the MME introductory algebra section and the control group consisted of 11 students enrolled in the lecture-based introductory algebra section.

At the community college, students self enroll into their courses. Many students use the published or online version of the class schedule to choose their classes. However, neither the published nor the online class schedule provides an indication of which classes are MME and which are lecture-based. Hence, when students register for introductory algebra, they do not necessarily know if they have enrolled in a MME or a lecture-based course. If the student has previously taken a course in the sequence of developmental mathematics, then it is possible that they would know whether the course was MME or lecture-based by asking their previous instructor or talking to other students whether this course will be MME or lecture -based. If this is a student's first semester at the college, or if they have not previously taken any mathematics courses at the college, then it is likely that they do not know whether the course will be MME or lecture-based.

Placement into Developmental Mathematics Courses

Students were placed into these courses by their performance on the Texas Success Initiative Assessment (TSIA), which is a mandatory computer-based assessment and diagnostic tool that must be given to all incoming first semester college students that do not meet the exemption criteria (Texas Higher Education Coordinating Board, 2013). The TSIA measures student performance in reading, writing, and mathematics. Students take the initial placement test, and if they do not meet the college-ready level score, they are required to take the additional diagnostic test in that subject. The scores range from 310-390. According to the TSIA manual, in the fall of 2013, the minimum score for placement into college-level mathematics courses was 350 (THECB, 2013). Students who do not achieve the minimum score are placed into the developmental education mathematics sequence.

Treatment and Control Group

The treatment group consisted of those students who enrolled in the MME introductory algebra section, which utilized the MyMathLab (2015) interactive mathematics program as the means of instruction. The control group consisted of those students who enrolled in the lecture-based introductory algebra section. The class had the material presented in a lecture-only format by the class instructor, "Dr. Bunch."

Participant Demographics

The questionnaire given on the first day of class collected student information including: (a) age, (b) gender, (c) ethnicity, (d) employment status, and (e) disability status. A total of 21 students from both sections of the course completed the questionnaire. Table 3.1 presents the results of the questionnaire by group.

Table 3.1 Participant Demographic Data by Section

	MME	Lecture
Ethnicity		
African American	40%	55%
Hispanic	50%	45%
Caucasian	10%	0%
Age		
18-20	10%	9%
20-25	20%	18%
26-30	30%	9%
31-35	30%	18%
36-40	0%	18%
41-45	0%	27%
46-50	10%	0%
Hours worked per week		
Unemployed	44%	73%
20-30	0%	9%
30-40	44%	9%
40+	11%	9%

Age of students

Over 50% of the students were over 30 years old (see Figure 3.1). Of the students, 10% were between 18 and 20 years old. Students who were between 20 and 25 years old made up 20% of the participants, and another 20% of the students were between 26 and 30 years old. Students who were between 31 and 35 years old made up 25% of the participants. Ten percent of the students were between 36 and 40 years old. Finally, 15% of students were 41 and 45 years old; the majority (80%) of students were female.

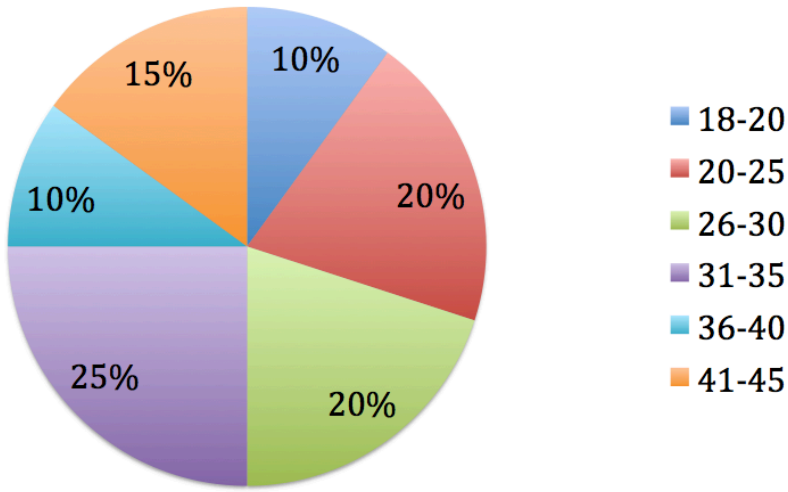

Figure 3.1 Percentages of Age of Students

Ethnicity of students

Student ethnicity is shown in Figure 3.2. African American and Hispanic students each comprised 48% of the sample population, with 10 students from each ethnic demographic. One of the students was Caucasian, comprising 4% of the sample population.

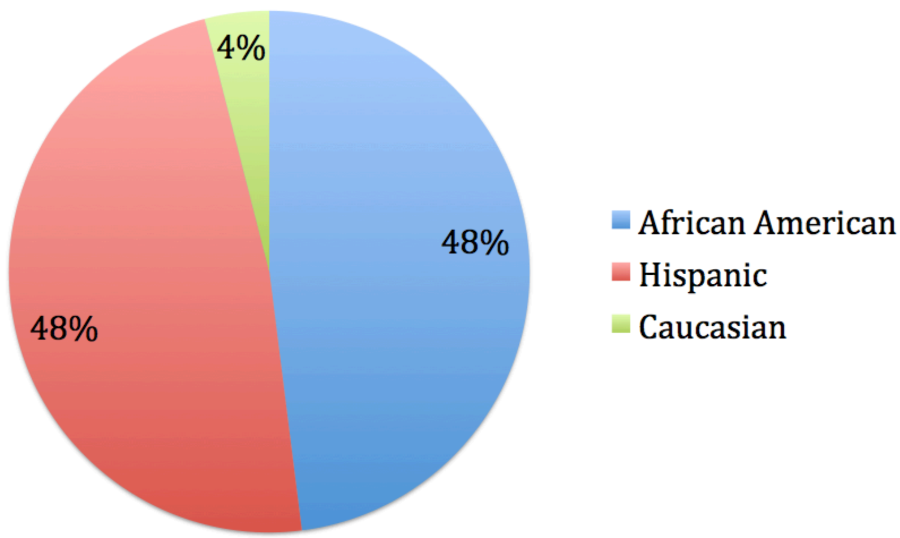

Figure 3.2 Percentages of Ethnicity of Students

Student hours of employment

Figure 3.3 depicts student hours of employment. Students who worked at least part time made up 53% of the population. Students who did not work comprised 47% of the population and students who worked over 40 hours per week comprised 37% of the population. Students who worked 30 to 40 hours per week comprised 5% of the population, and students who worked 20 to 30 hours per week comprised 11% of the population.

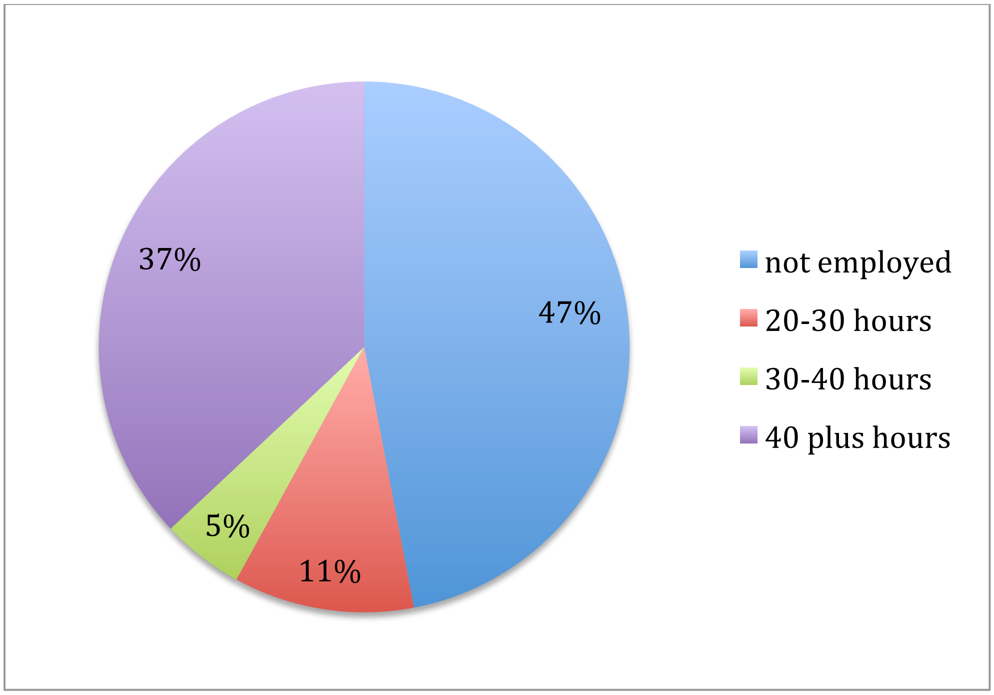

Figure 3.3 Percentages of Student Hours of Employment per Week

Student disability status

There were two students in the class who reported having a disability. One student had a learning disability (LD), and the other student had a physical disability but did not specify further details about the physical disability. Students (n = 19) reported having no disabilities. The student with the LD was enrolled in the lecture-based course but was also interviewed. She did not ask for any accommodations in the lecture-based course. The student who reported having a physical disability was enrolled in the MME course but did not give an interview. Even though only one student reported having a LD, all students who were interviewed discussed experiencing mathematics difficulties. Some of the students reported dropping out or failing mathematics courses in high school. Also, over 50% of the students were over the age of 30 when starting this course, and some mentioned in the student interviews that they had been out of school and had no mathematics instruction for over 20 years. Given the age of the students and their time out of high school, it is possible that some of them would have been identified as having a LD if they had been in school more recently. In the past, an identification of mathematics disability (MD) has been based upon the IQ-achievement discrepancy using commercial achievement tests, which resulted in few MD identifications (Fuchs, Compton, Fuchs, Paulsen, Bryant & Hamlett, 2005). Mazzocco and Meyers (2003) stated that depending on which measures are used, different groups of children are identified as having MD. Mazzocco and Meyers (2003) also stated that defining MD is complex, because “several different domains of function have been linked to poor math achievement, primarily reading-related, memory, visuospatial skills, and/or executive skills” (p. 219).

Student Attrition

Three students dropped out of the MME course and two students dropped out of the lecture course. One student finished the 8-week MME course four weeks early and therefore posttest data could not be gathered from that student. This study was set to compare an 8-week MME course to an eight-week lecture course, but because of student attrition and low numbers to begin with in the eight-week MME section, data was collected from a 5-week MME course for comparison. Because of the low number of enrollment into the 8-week MME course, students in the 5-week MME course were also given the pretest and questionnaire on the first day of class, and the rest of the data collection that was planned for the 8-week course took place in the 5-week course instead. Although there were 11 students in each group in the beginning of the course, by the end of the course there were only eight students in the MME group and nine students in the lecture group.

SETTING

The setting of this study was Southeast College, a branch of Houston Community College (HCC). This branch of HCC opened in 1991. Southeast College uses multimedia-enhanced instruction (MME) as a major component of the developmental mathematics program.

For the summer 2015 semester, there were three introductory algebra courses offered. Two courses were taught via MME instruction, and the other course was taught via lecture-based instruction. One of the mathematics instructors, “Dr. Bunch,” taught a Multimedia-enhanced (MME) course and the lecture-based course, and the other mathematics instructor, “Mr. Franco,” taught a MME course. Both mathematics instructors have taught introductory algebra via MME instruction and introductory algebra via lecture-based instruction for over 10 years at the college. Both instructors had over 40 years of teaching experience at the K through 12 and postsecondary levels. Both instructors were white males over the age of 60.

Treatment Group Setting

The computer lab used for this course was one of four labs (Figure 3.4). Inside this classroom lab were three long tables. The first two tables each had 14 computers that were arranged back-to-back, with seven sets of two computers. The third table had eight computers arranged back-to-back as well.

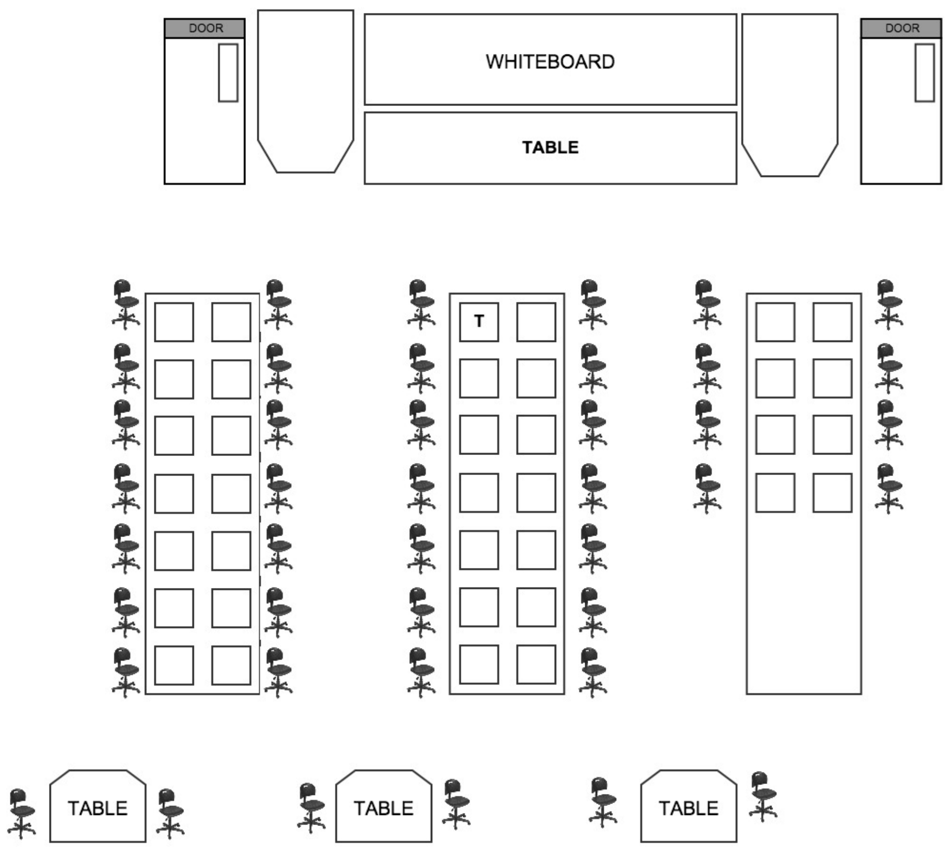

Figure 3.4: Computer Lab Classroom

The instructor, "Dr. Franco" was present in the computer lab for the entire 90-min session each class period. In the beginning of each class, "Dr. Franco" called roll and marked absences. There was a teacher computer station that connected to a projector. "Dr. Franco" used this to check the progress of each student. After assessing the students' progress, he consulted with those students who were falling behind in the class, which was apparent from quiz scores and a screen that showed which quizzes still needed to be taken by the student.

"Dr. Franco" also consulted with those who had specific problems and tutored any students who needed help. He suggested specific videos for the student to watch if they were struggling with the material. He was familiar enough with the curriculum that most of the time he could assess a student's need for assistance simply by watching their computer screen. The textbook used for this course was *Prealgebra and Introductory Algebra* (Bittinger, Ellenbogen, Beecher & Johnson, 2011).

Control Group Setting

The lecture-based course met in a classroom that contained nine tables with two chairs at each table. There was a dry-erase board at the front of the classroom. The instructor in the lecture-based course, "Dr. Bunch," did not check the progress of each student, as the class was taught as a whole. The students in the lecture-based course used the same textbook as the students in the MME course, *Prealgebra and Introductory Algebra* (Bittinger et al., 2011).

RESEARCH DESIGN

To address the research questions in this study, a mixed-methods design was used that included the collection of both quantitative and qualitative data to provide an in-depth analysis of MME instruction in an introductory algebra developmental mathematics course. A mixed methods design can work to balance the deficits of one genre with the assets of another (Miles et al., 2014).

Quantitative

A quasi-experimental nonrandomized pretest/posttest control group research design was used for the first and second research questions (Mertens, 2005). In the diagram below, O represents pretests and posttests, and T represents the treatment. The letters above the dotted line signify the treatment group, and the letters below the dotted line signify the control group.

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O   T  O
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O        O
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The independent variable in this study was the mode of instruction: MME instruction or lecture-based instruction. Student mathematics achievement was the dependent variable. The use of a pretest provides a covariate to statistically equate the two groups. The use of a control group allowed posttest differences to be attributed to treatment differences rather than other variables. A “true” experimental design could not be used because randomization was not possible with an intact group.

Qualitative

A phenomenological research design was used to collect qualitative data to answer the fourth and fifth research questions. The philosophy of phenomenology is that every individual has a subjective experience. A researcher may use a phenomenological approach when seeking knowledge about individual perceptions and perspectives of an experience, event, or circumstance (Mertens, 2005). In this study, the researcher was seeking to obtain the participants experience in being in the multimedia-enhanced developmental mathematics course. Phenomenology focuses on the lived experiences from the perspective of the individual, and can be used to build "complex meanings…out of simple units of direct experience" (Merriam, 2002, p. 118). Semiotic phenomenology is a methodology for analyzing conscious experience, focusing on language as a medium of expression (Wolff, 2002), as "words are the basic form in which data are found" (Miles, Huberman, & Saldaña, 2014). Descriptions, which are the participants' words describing the phenomenon, were gathered through the interviews.

PROCEDURES

Consent and Anonymity

This study was submitted for approval to conduct research to The University of Texas at Austin Internal Review Board (IRB; see Appendix A). The researcher collected letters of consent from the participants. Data was collected from the participating mathematics instructors, "Dr. Bunch" and "Dr. Franco." The participating mathematics instructors ensured subjects' privacy and confidentiality by removing all student identifiers on the pretests and posttests and assigning a random number to each student.

Quantitative Measures

Pretest, posttest, and final exam

The pretest and posttest were the same document and was collaboratively created by the faculty of the mathematics department at Southeast College (see Appendix B). The objective of the pretest was to measure students existing knowledge of the concepts that would be taught in the class. It was designed specifically to what was taught in the course. It was a paper-and-pencil test that contained 20 multiple-choice questions with a scantron answer sheet and was scored by the scantron machine. The posttest was the same test as the pretest, but it was given at the end of the semester. The final exam for the course was created each semester by the faculty of the mathematics department at Southeast College (see Appendix C). The final exam was scored in the same manner that the pretest and posttest were scored.

Questionnaire

The questionnaire was designed to collect data such as: student demographics, socioeconomic status, disability status, employment status, previous developmental mathematics courses taken, and general disposition toward mathematics (see Appendix D). The questionnaire was given on the first day of class after the students took the pretest.

Course survey

To collect data on student satisfaction in the lecture-based and MME course a 10-item course survey was developed by "Dr. Bunch," the instructor of the lecture-based course. This survey was given at the end of the course in the lecture-based section, and an electronic version of the survey was given to the students in the MME section after the course was completed (see Appendix E).

Fidelity of Treatment and Comparison

As a means of determining fidelity of treatment, two fidelity checklists were developed by the researcher (see Appendix F). The first document, Fidelity of Treatment and Control Conditions was a 6-item checklist to determine if the following took place in both treatment and comparison conditions: (a) lecture, (b) small group, (c) technology, (d) opportunities for practice, (e) one-on-one instruction, and (f) monitoring progress. The second document, Fidelity of Treatment Condition was a 6-item checklist to determine if the following took place in the treatment condition: (a) instructor checks individual student progress on teacher computer, (b) instructor walks up and down through the lab, asking each student what they need help with, (c) instructor gives one-on-one help in the back of the classroom, (d) instructor works with student at their computer, (e) instructor teaches to the whole class problems missed on most recent unit test, and (f) instructor reviews the final exam problems and works problems in front of whole class.

Qualitative Measures

Interviews

One-on-one interviews were conducted following the researcher-created interview guide (see Appendix G). The interview guide was formed in part based on the answers to the questionnaires, and in part based on observations. It served as a follow-up to the questionnaires and observations. The interview guide contained the following topics: interviewee's purpose for taking the course, career aspirations (post-course goals), history of learning disabilities (LD) or struggles with mathematics, interviewee's life experiences with K through 12 mathematics instruction, positive and negative experiences with mathematics in school, participants' use of computers, and access to accommodations.

Procedures

On the first day of class, students in both groups were given a student questionnaire containing questions about their gender, age, ethnicity, student status, and socioeconomic status, and employment. When the students finished the questionnaire, they put it into a large envelope so that neither the instructor nor the researcher was able to see their answers. The questionnaire was anonymous. After the students turned in the questionnaire, they were given the pretest to complete before they left the class.

As a means of ensuring fidelity of the treatment, the researcher conducted observations throughout the period of the five and eight-week courses, and used a fidelity checklist to determine the components of instruction in both settings (See Appendix F). The researcher observed approximately two sessions in each class every week, except for the second week of class when the college was closed due to severe flooding. Observations occurred between June 8, 2015, and July 29, 2015, for a total of 16 observations (see Appendix H for specific dates).

Interview procedures

Starting during week 5, semi-structured interviews were conducted to gain additional insights about the students who were enrolled in the multi-media enhanced section of the course. Students volunteered for the interviews in both the MME and lecture-based section. The students in the 5-week MME course were interviewed during weeks 4 and 5. Students in the 8-week lecture-based course were interviewed during week 8. Eight interviews were conducted to determine the student perceptions of the barriers and facilitators to learning in the MME section of the introductory algebra course. Eight students were interviewed; four students were interviewed from each section (see Appendix G for the interview protocol). Each interview lasted between 20-45 min.

The interviews took place in the back corner of the large computer lab when the classes were not in session. The researcher sat near the interviewee but not across the table. A microphone was positioned on the table to record both the researcher and the interviewee. The interviews were recorded on a laptop computer. The laptop was turned away from both the interviewee and the researcher so as not to intimidate the interviewee. The researcher took brief notes, so as not to distract the interviewee.

The researcher introduced herself and gave a brief description of the purpose of the interview: “The purpose of the interview is to gain insight on your experience of being in a multimedia-enhanced developmental mathematics course.” The researcher then explained the structure of the interview and restated how long the interview session should last. The researcher told the subject how the data would be used, and how anonymity would be preserved.

When the participant answered an open-ended question, the researcher summarized or paraphrased back to the participant what had been said, to confirm the intended meaning. This also served as a prompt for the participant to expand on what was said. When all topics and points on the interview guide had been covered, the researcher shared the main points that the interviewee said as the first step in the member check process.

Treatment group

The students in the treatment group came to the computer lab Monday through Thursday for 3.2 hours per session, for a total of 12.8 hours per week. The course lasted five weeks. Students spent a total of 64 hours in the computer lab. The lab was also open for extra sessions, in case of student absences, from 8am to 9pm Monday through Friday, and on Saturday from 8am to 5pm. The computer lab was closed on Sunday. The computer lab was available to both the treatment and control group; however, only the treatment group had access to the MyMathLab program.

When students came to the computer lab for their class, they had individual computers for their own use. Students were also able to access the MyMathLab program outside of class time if they need additional time to work on homework assignments.

The students in the treatment group had their entire course taught via MyMathLab, a web-based interactive mathematics program. This course used MyMathLab in a mastery-learning framework (see Figure 3.5). Students were given an orientation on the first day of class that: (a) provided students with a course ID needed in order to register into MyMathLab, (b) demonstrated how to access MyMathLab, and (c) pointed out the various learning activities found within the program. Because MyMathLab is a web-based program, students could access the program from home or work if they needed extra time to work on their assignments.

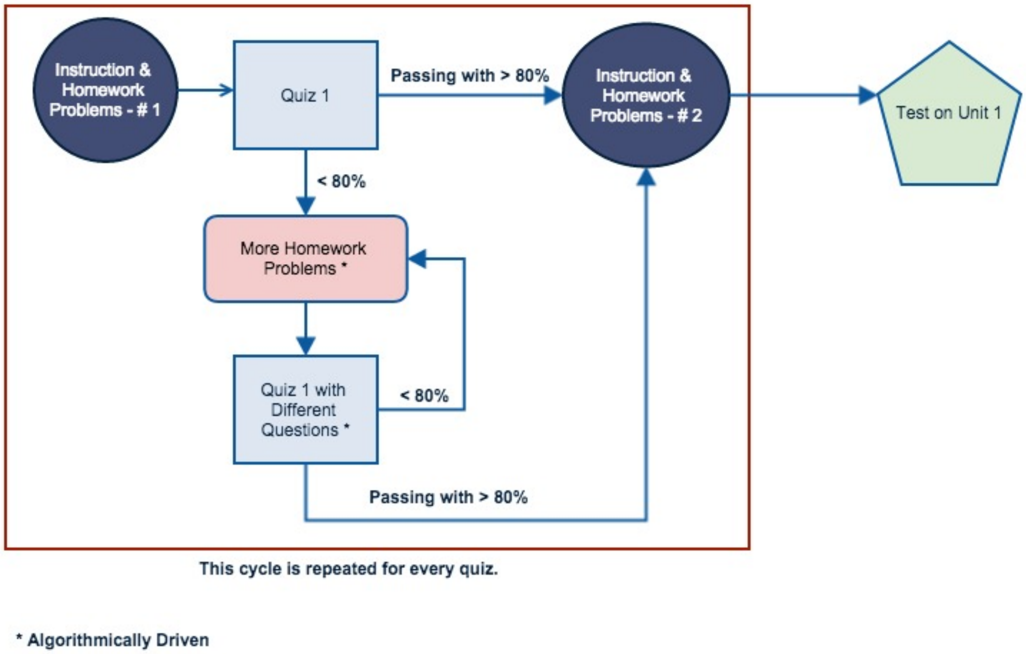


Figure 3.5 Mastery Learning in the Context of the Multimedia-Enhanced Course

When students logged in, they were taken to the homework assignment screen (see Figure 3.6), where they accessed homework assignments, saw due dates, and grades for completed assignments. The link to the homework assignment remained active until they were no longer allowed to make changes to their homework.

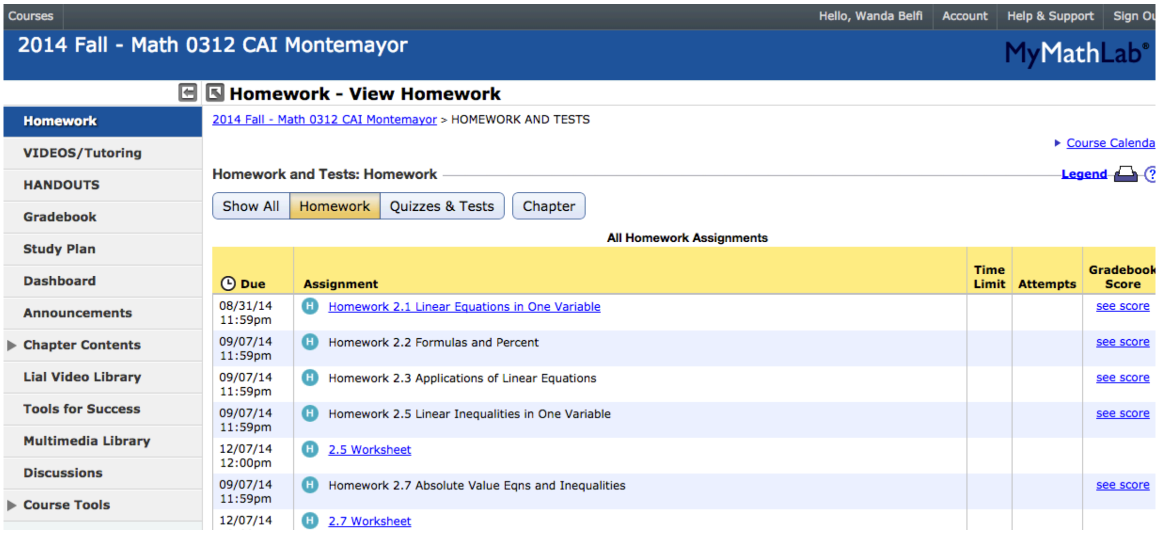


Figure 3.6. Home Page for the Course

The homework assignments consisted of videos to watch and questions to answer related to each video (see Figures 3.7 and 3.8). The video was an instructor-created mini-lesson that the students could watch to learn the concept (see Figure 3.9). The videos were made on a computer using Camtasia. Camtasia is a software program that allows the computer screen to be recorded and audio captured at the same time. This is a way to create a video demonstration of doing something at a computer for a tutorial purpose. In this instance, the instructor, "Dr. Bunch," created a PowerPoint presentation of the mini-lesson, and used the slides to give a visual aide to what he was teaching. He also worked a sample mathematics problem on the computer screen and explained in audio how he was working the problem and the logic to the solution of the problem.

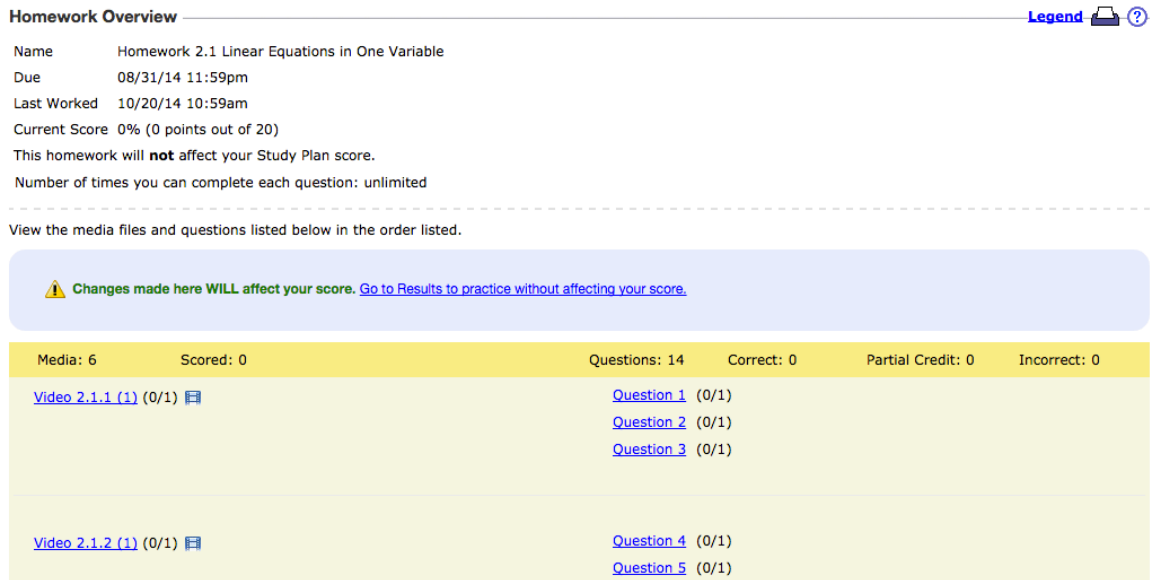


Figure 3.7: Homework Assignment Screen – Top Half

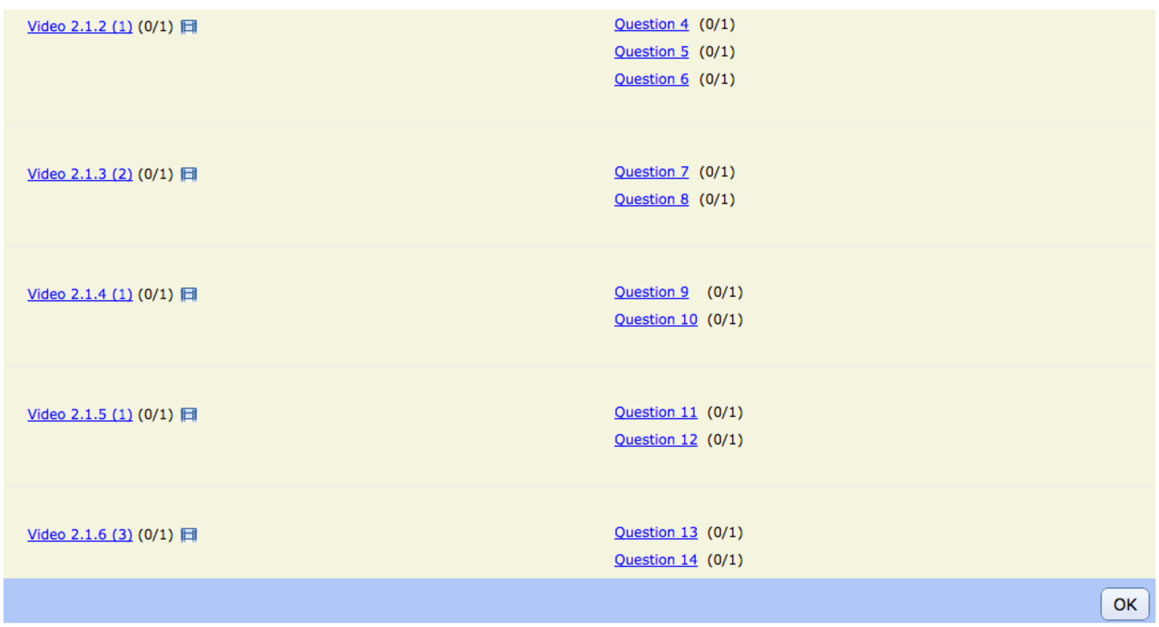


Figure 3.8: Homework Assignment Screen – Bottom Half

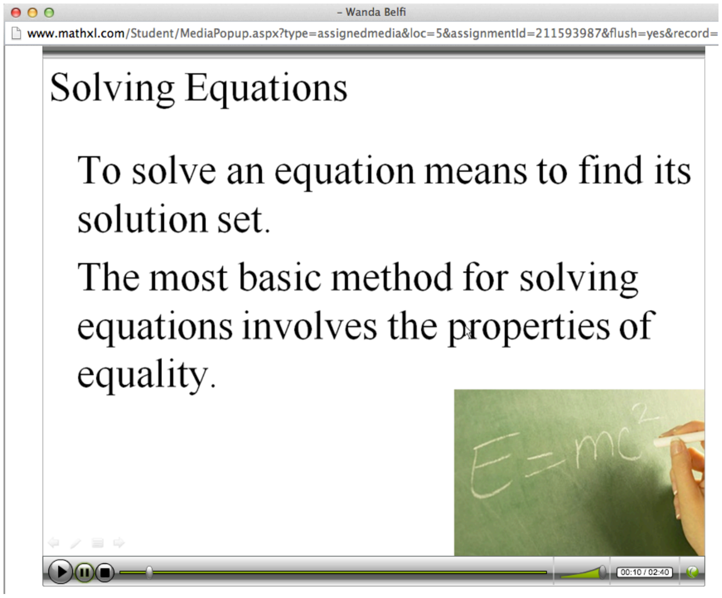


Figure 3.9: Instructor-Created Video

Students were given a question to assess whether or not they learned the material that was just presented (see Figure 3.10). The student had a list of options to help solve the problem. There was a choice to watch "Assigned Media," which was the video that was already presented in the homework.

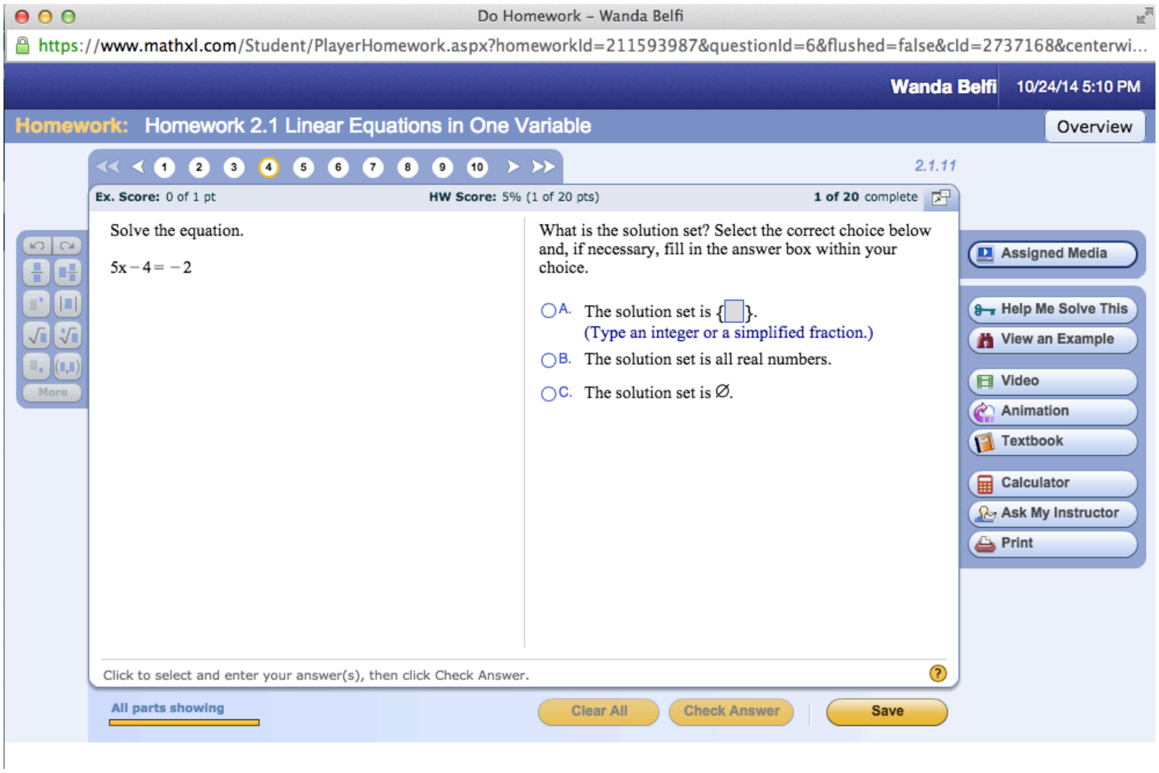


Figure 3.10: Homework Question

If the student selected "Help Me Solve This," a step-by-step guide appeared on the screen, prompting the student to click "Continue" to see each step to solve the problem (see Figure 3.11). Using the "Help Me Solve This" function, the student was able to check the steps of their work as they go along, rather than waiting to see their grade to determine if they missed the question (see Figures 3.12 and 3.13). As students solved a step, the program took them to the next step (see Figure 3.14).

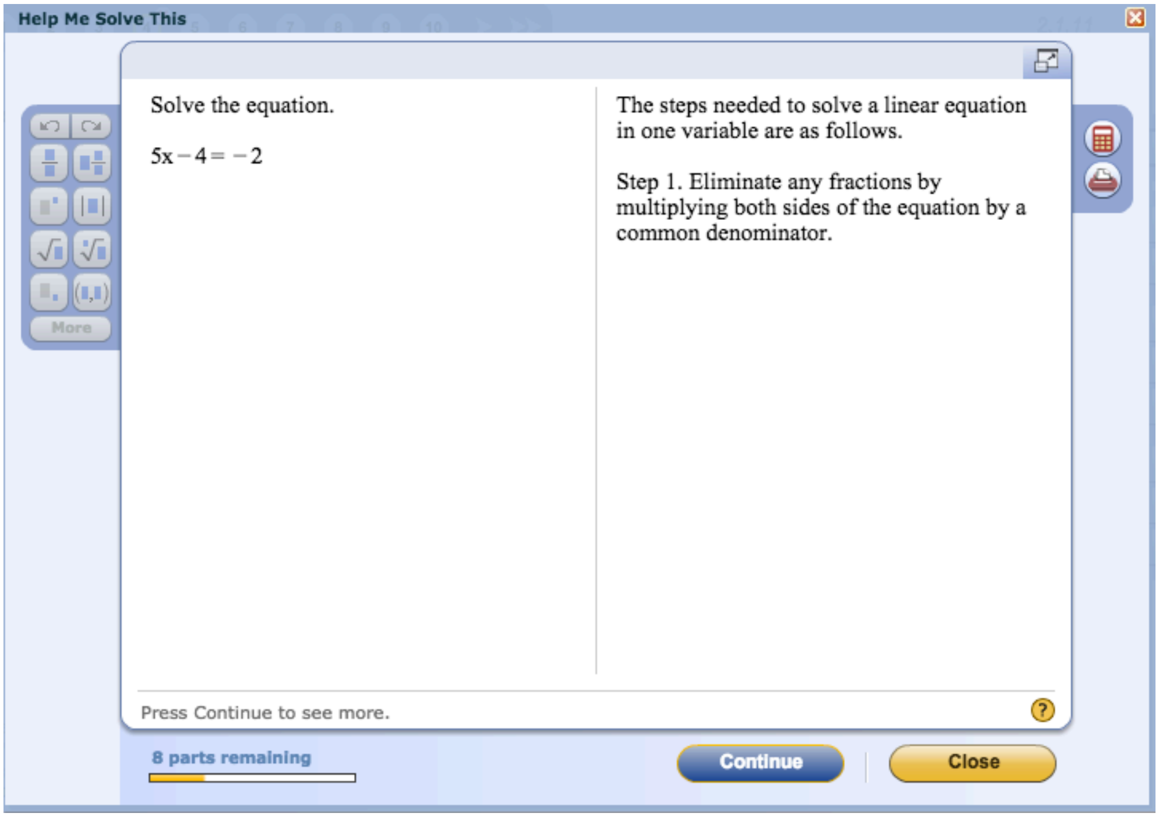


Figure 3.11: Help Me Solve This

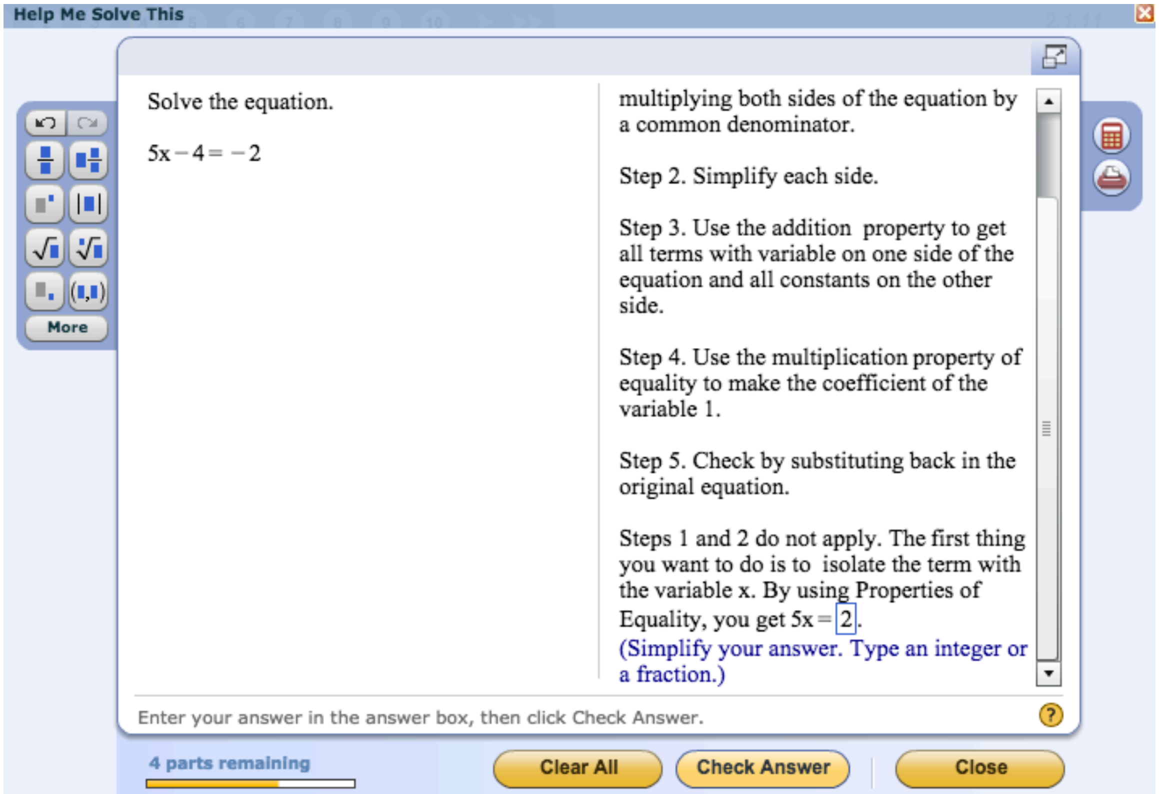


Figure 3.12: Help Me Solve This, Further Steps

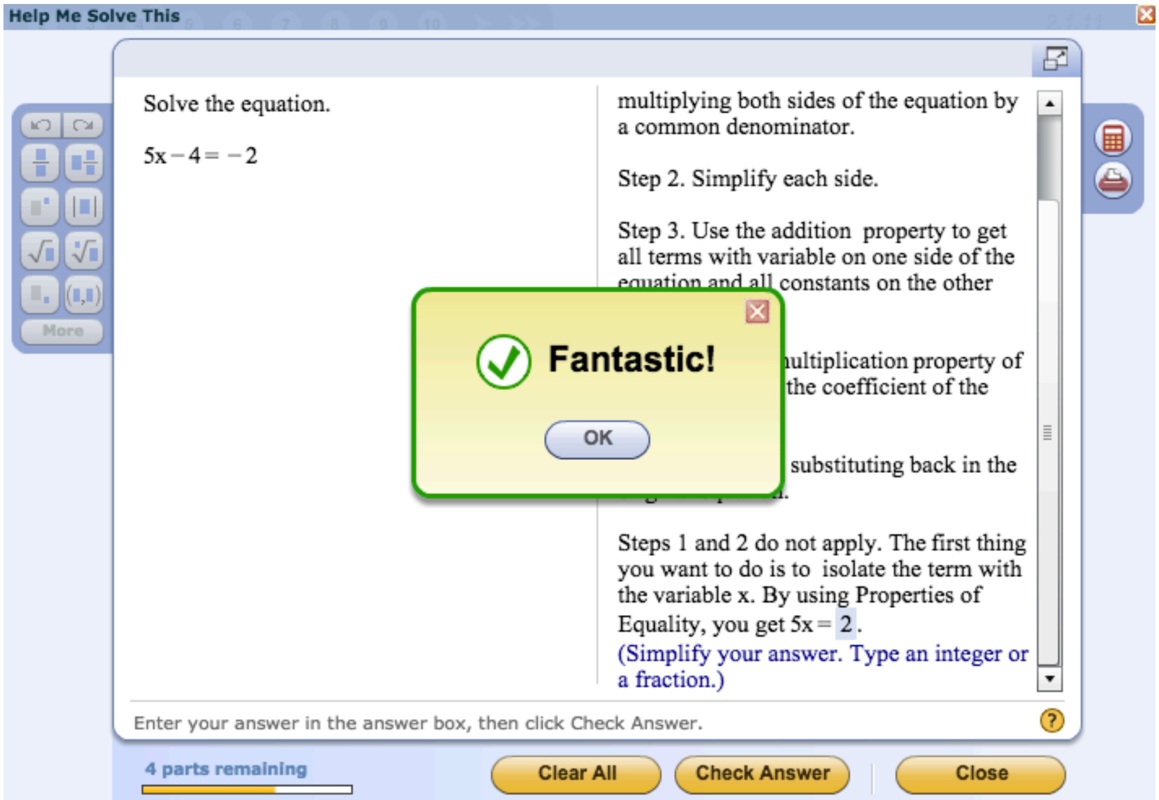


Figure 3.13: Help Me Solve This, Student Did a Step Correctly

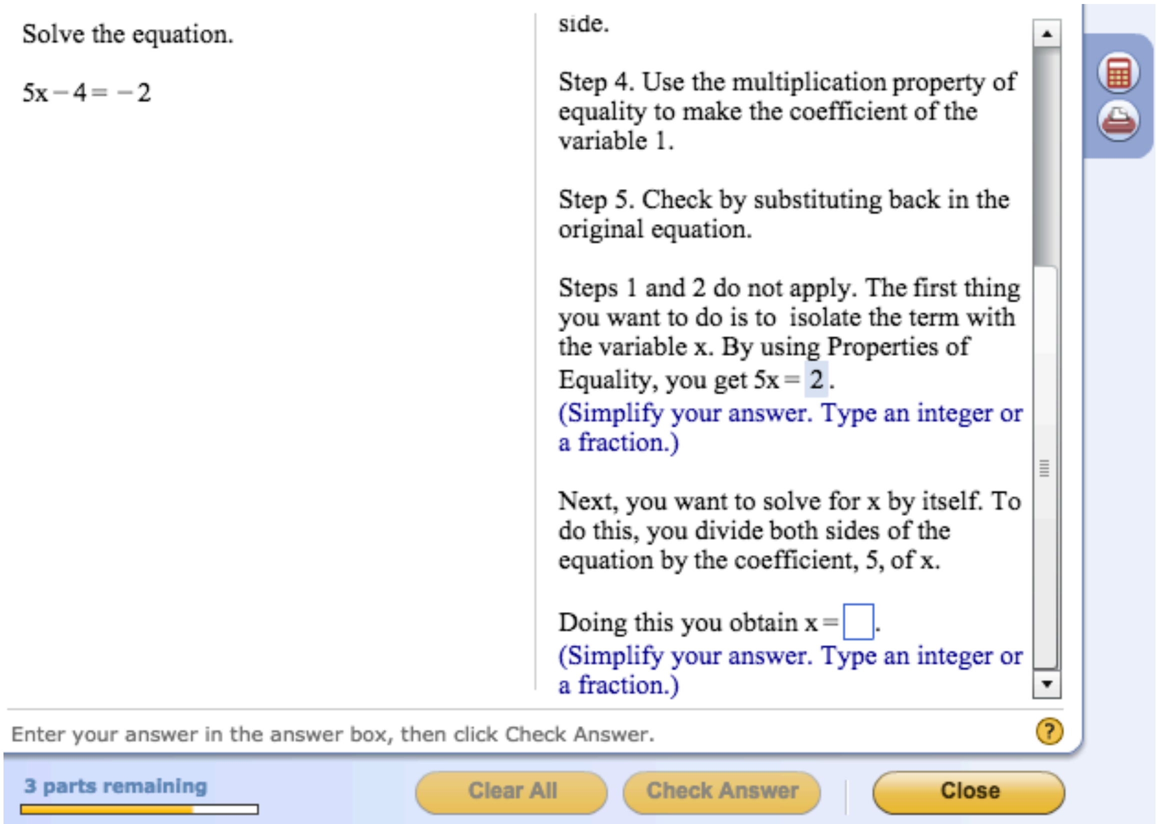


Figure 3.14: Help Me Solve This, Final Step

The student also had the choice to watch the video. This video option was different from the "Assigned Media" video, which was created by "Dr. Bunch." The "Video" button played an actual video of an instructor working the problem at a board and explaining the steps (see Figure 3.15). This "video" was created by Pearson and provided in the original MyMathLab software.

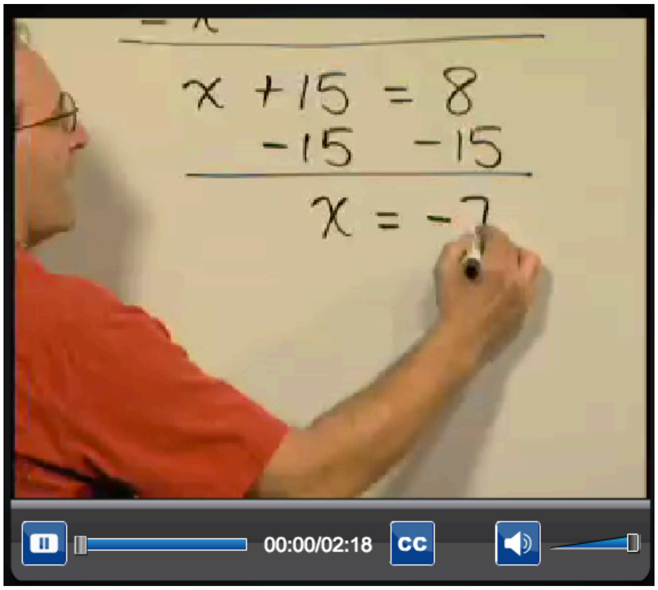


Figure 3.15: Pearson-Created Video

Students could also click “Animation” to learn the steps to solving a similar problem. This was yet another format to help the students learn the concept. The animation guided the student to solve the problem by clicking on the terms in the problem and completing the step for them. During the final piece of the animation the students could check their work (see Figures 3.16, 3.17, and 3.18).

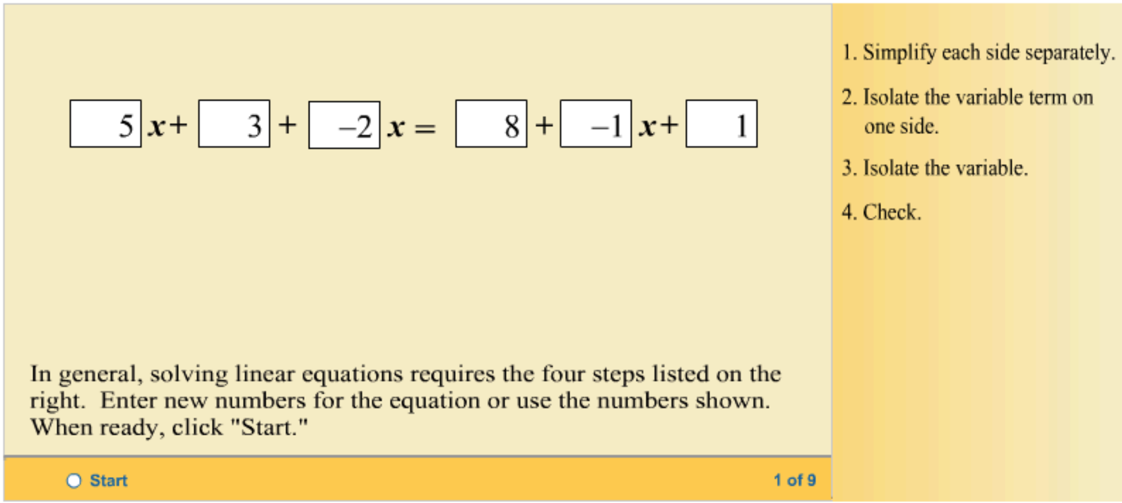


Figure 3.16: Animation, Students Can Enter Their Own Coefficients

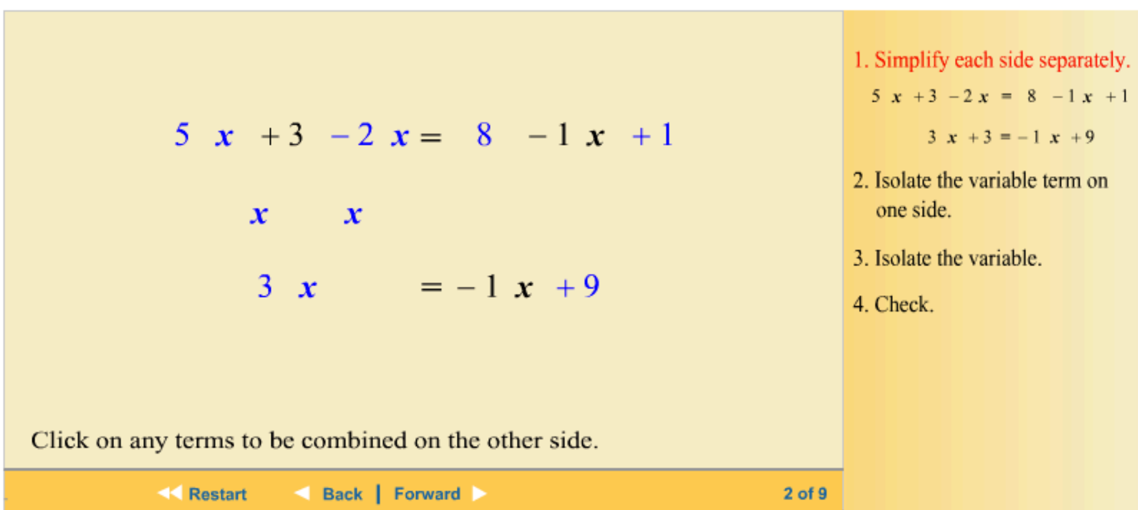


Figure 3.17: Animation, Step 1

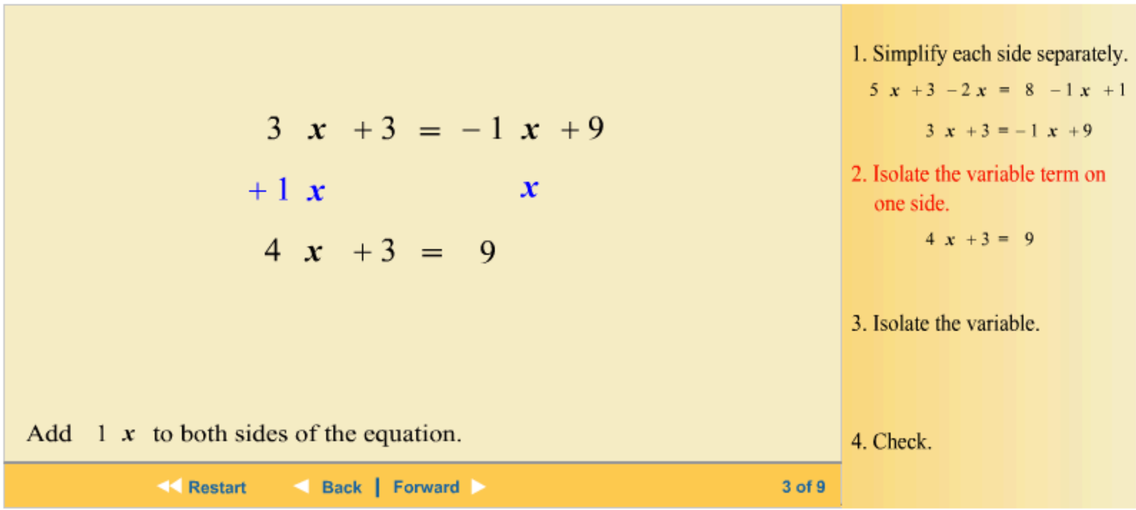


Figure 3.18: Animation, Step 2

Another resource for the student was the electronic version of the textbook. The student could click the "Textbook" button to see the exact place in the textbook where the concept was taught (Figure 3.19).

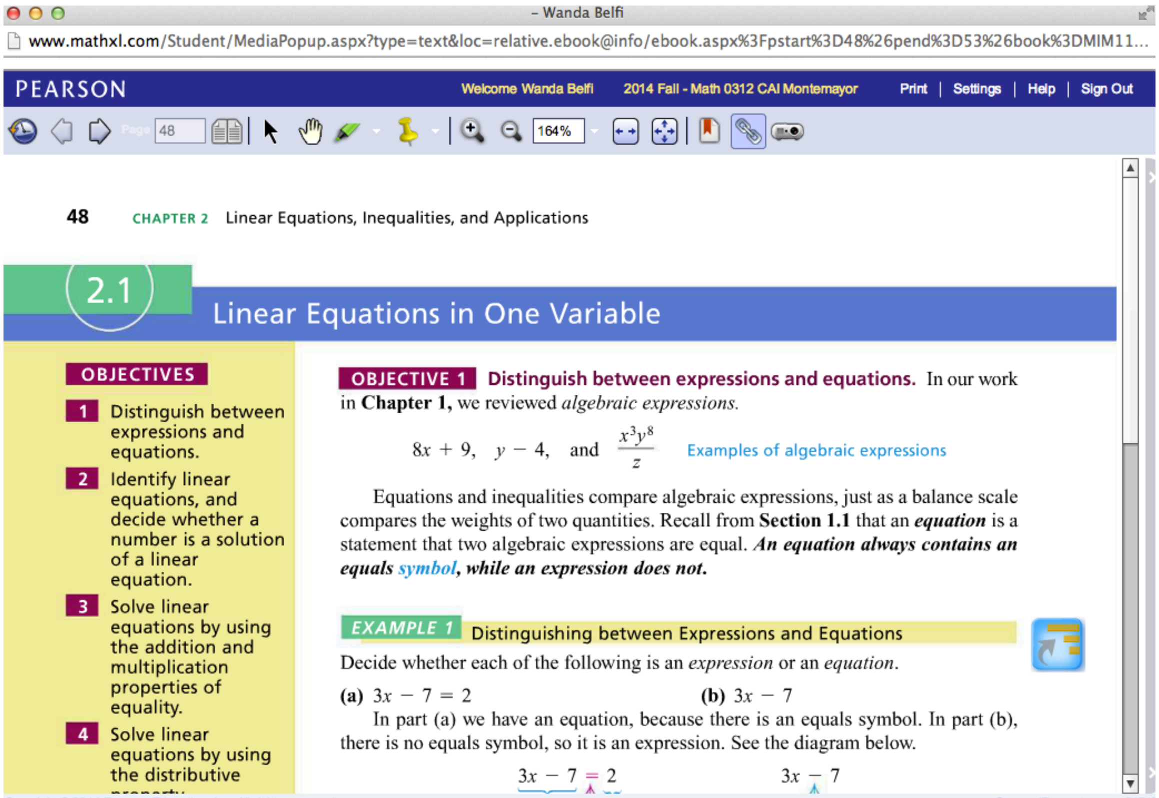


Figure 3.19: Sample Textbook Page

When the students clicked the "Ask My Instructor" button, a window popped open to allow the student to email the instructor, "Dr. Franco," and included a reference to the problem (Figure 3.20).

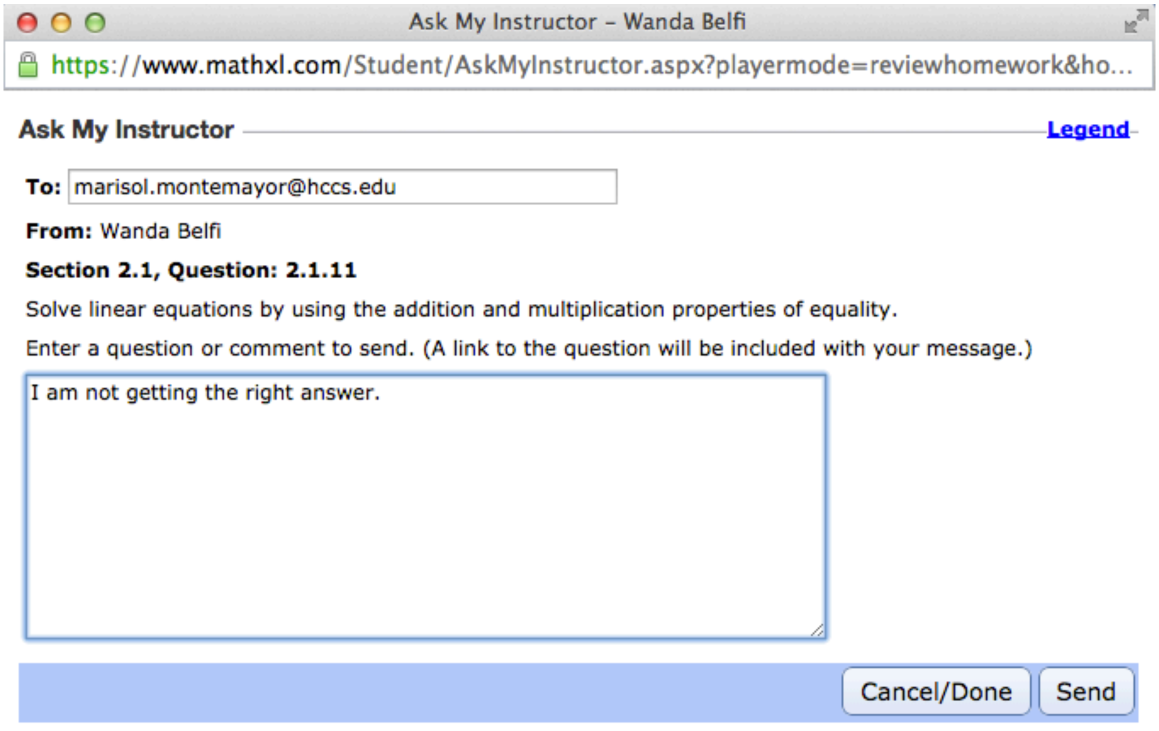


Figure 3.20: Ask My Instructor Email Dialogue

Students' final grade average for the course was determined by the weekly quizzes, examinations, and the final exam. Grades were assigned in the same manner in both the MME and lecture-based course.

Control group

Students in the lecture-based introductory algebra class were required to report to a lecture classroom during their assigned class time four times a week for 2 hours each class period over eight weeks. The students met for a total of 64 hours of instruction. These students also received a course syllabus that listed the material to be taught as predetermined by the developmental mathematics committee of the community college. The course syllabus indicated what objectives would be taught each week. The students received only lecture-based mathematics instruction. The students in the control group and the treatment group received the same content instruction but in different formats. The instructor, “Dr. Bunch,” created PowerPoint presentations to teach the mathematics from the textbook, which was the same textbook used in the treatment group. “Dr. Bunch” worked problems using the PowerPoint slides to show the problems and the progression through the solution. He also worked problems on the board. He asked students to help solve the problems and what step came next. Students called out answers to finish the work on the problems. The instructor used the dry erase board if more instruction was needed for the students in the class to understand the problem.

Students in the control group were not given a course ID to access MyMathLab. In other words, the students in the control group received only lectures that covered the required objectives in the course syllabus. Students were allowed to take notes and ask questions if necessary. The students were also given homework assignments assigned from the designated course textbook to complete outside of class. Students were also required to take weekly quizzes, three major examinations, and a departmental final examination. Students’ final grade average for the course was determined by the weekly quizzes, examinations, and the final exam. Both the treatment and control groups were assigned the same homework problems and took the same examinations. Both groups were also told how to access instructor-created videos for use outside of class.

The participating instructors maintained student attendance records for the control and treatment groups. Also, the participating instructors maintained student progress records for both groups. A pretest was also given on the first class day. The posttest was given on the day before the last class day. The pretest and posttest was the same that was given to the treatment group. This was a paper and pencil test, and students recorded their answers on a scantron. Students had 1 hour to take the test. The final exam was given in the same manner on the last day of class. The pretest, posttest, and final exam were all paper and pencil tests in both the treatment and control group.

DATA ANALYSIS

Quantitative

Research question 1

This study used a quasi-experimental nonrandomized, pretest posttest control group design. The two groups were "equated" through the use of pretest scores, which served as the covariate. An independent sample *t* test was performed to determine that there was no significant difference in the performance on the pretest between the MME and lecture-based section.

An ANCOVA statistical procedure was performed on the pretest and final exam to determine if there was a statistically significant difference in achievement of mathematics between the students in the two groups. Data from the questionnaires were analyzed to determine the demographic information for the students.

Research question 2

An ANCOVA statistical procedure was performed on the pretest and posttest to determine if there was a statistically significant difference in achievement of mathematics between the students in the MME section and the lecture-based section.

Research question 3

An ANOVA statistical procedure was performed on the course survey to determine if there was a statistically significant difference in satisfaction between the students in the MME section and the lecture-based section. The independent variable was the class type, and the dependent variable was the survey score. The researcher scored the 11 submitted student satisfaction surveys. The surveys were scored in the following manner: a response-type of "strongly agree" was given five points; a response type of "agree" was given four points; a response type of "neither agree nor disagree" was given three points; a response type of "disagree" was given two points; and a response type of "strongly disagree" was given one point. Therefore, based on the sum of the ten responses, each student was given a satisfaction score based on their answers to the survey.

Qualitative

Research questions 4 and 5

To determine the students' perceptions of the barriers and facilitators to learning in the MME section and the lecture-based section, and to determine the students' past experiences with mathematics and dispositions towards mathematics learning in general in both the multimedia-enhanced course and the lecture-based course. the interviews were transcribed. The researcher transcribed the interviews from both the MME section and the lecture-based section so that phenomenological reduction could take place. Miles et al. (2014) argued that the word reduction should not be used. They instead offered the word condensation, since the data are not being reduced or watered down, but collected and categorized together. This is the process of discovering emergent themes from the transcriptions, as the themes may be supported by similar comments from several participants (Wolff, 2002) Chunks of the data (transcribed interview text) were assigned descriptive labels (Miles et al., 2014).

A code is a label that is generated by the researcher to attribute interpreted meaning to each phrase so that patterns may be detected, categorized, and analyzed, and so that theory may be built (Miles, Huberman, & Saldaña, 2014). These labels emerged as the researcher discovered themes within the individual participant's interview, as well as across the interviews of several participants (Wolff, 2002). The utterances of the interviewees in this study were gathered under thematic headings, and numbers were written along with the phrases, to signify which interviewee said which phrase.

Themes were then grouped into more encompassing themes, and an interpretation of the interrelatedness of the themes were formed (Wolff, 2002). The data was then displayed in a table (see Tables 4.9 and 4.10). Miles et al. (2014) recommended using a visual or a graphic to make sense of the data. Designing the display and choosing the data to be displayed were part of the analysis (see Figure 4.14). The final step was to draw conclusions and make interpretations (Miles et al., 2014; Wolff, 2002). The researcher used the data from the test scores, questionnaires, interviews, and member checks as a means of triangulation. The data from each were analyzed to compare against the data from the other.

Chapter 4: Results

This chapter presents the results of the study. A mixed-methods design was used because "quantitative research does not adequately investigate personal stories and meanings or deeply probe the perspectives of individuals," and "qualitative research does not enable us to generalize from a small group of people to a large population" (Creswell, 2014, p. 14). The purpose of this study was to investigate whether students in the multimedia-enhanced (MME) section of an introductory algebra course performed better on a final exam and a posttest compared to students in a traditional lecture-based course. The second purpose of the study was to identify the perceived barriers and facilitators to students' learning in the MME course section. The final purpose of this study was to determine the student satisfaction between the two conditions. A mixed-methods approach was used to collect both quantitative and qualitative date to answer the following five research questions:

1. Is there a statistically significant difference in the performance on an algebra course final exam between students taught in a multimedia-enhanced course and students taught with lecture-based instruction in an introductory algebra course with pretest score as the covariate?

2. Is there a statistically significant difference in posttest scores between students taught in a multimedia-enhanced course and students taught with lecture-based instruction in an introductory algebra course with pretest score as the covariate?

3. Is there a significant difference in levels of student satisfaction between the multimedia-enhanced section and the traditional lecture-based section?

4. What are the students' perceptions of the barriers and facilitators to their learning in the multimedia-enhanced course and the lecture-based course?

5. What are the students' past experiences with mathematics and dispositions towards mathematics learning in general in both the multimedia-enhanced course and the lecture-based course?

Quantitative results are presented with qualitative results following. First, the results of the analysis of covariance of the scores on the final exam comparing students in the MME course to the traditional lecture-based course are given. Second, the results of the analysis of covariance of the scores on the posttest comparing students in the MME course to the traditional lecture-based course are given. Third, results from the student satisfaction survey are displayed.

Qualitative results from analysis of the interviews investigating students' perceptions of the barriers and facilitators in the MME section are presented to answer the third research question. Next, a visual representation of qualitative themes that emerged from the interviews is presented and the qualitative themes that emerged from the interviews discussed. Finally, a summary of the chapter is given.

Quantitative Results

Pretest

To determine that students in the MME and lecture-based groups had equivalent mathematics performance in the beginning of the course, the students in both groups were given a pretest on the first day of class. The average score on the pretest in the MME section was 29.09%, and the average score on the pretest in the lecture-based section was 29.09%. There was no difference between the two groups, showing that at the beginning of the course the two groups had an equal level of mathematics knowledge.

There was not a statistically significant difference between the mathematics achievement on the pretest of students who participated in the MME section of the course and the students who participated in the lecture-based section of the course. As shown in Table 4.1, the an independent sample *t*-test showed that the difference in pretest scores between the lecture-based group (n = 11, M = 29.09, SD = 8.01) and the MME group (n = 11, M = 29.09, SD = 20.23) were not statistically significant, $t(13.06) = 0$, $p = 1$.

Table 4.1 Results of t-test and Descriptive Statistics for Pretest

	Condition						95% CI for Mean Difference		
	MME			Lecture-Based					
	M	SD	n	M	SD	n		t	df
Pretest	29.09	20.23	11	29.09	8.01	11	-14.16, 14.16	0	13.06

Research Question 1

Descriptive data

A quasi-experimental mixed-methods research design was used to determine whether there was a significant difference in the performance on an algebra course final exam between students taught in a multimedia-enhanced course and students taught with lecture-based instruction in an introductory algebra course. A pretest was given at the beginning of the course to provide a covariate to equate the two groups of students. A total of 17 students took both the pretest and final exam. There were eight students from the MME section and nine students from the lecture-based section who took the pretest and the final exam. Table 4.2 presents the means and standard deviations (SD) for both conditions on the final exam. Five out of eight students in the MME course passed the final exam, and five out of nine students in the lecture-based course passed the final exam.

Table 4.2 Means and Standard Deviations for Final Exam

Group	Final Exam Means	*SD*	Number of Students in Sample
MME	69.4	16.8	8
Lecture	59.9	13.3	9

Analysis

A One-way ANCOVA was conducted to determine a statistically significant difference between the MME section and the lecture-based section on final exam scores controlling for the pretest scores. There was not a statistically significant difference between the mathematics achievement on the final exam of students who participated in the MME section of the course and the students who participated in the lecture-based section of the course, $F(1, 14) = 0.25$, $p = .624$ (see Table 4.3).

Table 4.3 Results Obtained from Analysis of Covariance for Final Exam

Source	Sum-of-Squares	*df*	Mean-Square	*F*	*p*
Pretest	1381.83	1	1381.83	9.66	0.008
Between Groups	35.94	1	35.94	.025	0.624
Within Groups	2003.16	14	143.08		

Research Question 2

Descriptive data

A quasi-experimental mixed-methods research design was used to determine whether there was a significant difference in the performance on a posttest between students taught in a multimedia-enhanced course and students taught with lecture-based instruction in an introductory algebra course. A pretest was given at the beginning of the course to provide a covariate to equate the two groups of students. A total of 15 students took both the pretest and the posttest. There were seven students from the MME section and eight students from the lecture-based section who took both the pretest and the posttest. Table 4.4 presents the means and standard deviations (SD) for both conditions on the posttest.

Table 4.4 Means and Standard Deviations for Posttest

Group	Posttest Means	*SD*	Number of Students in Sample
MME	56.4	11.8	7
Lecture	58.8	15.5	8

Analysis

A one-way ANCOVA was conducted to determine a statistically significant difference between the MME section and the lecture-based section on posttest scores controlling for the pretest scores. There was not a statistically significant difference between the mathematics achievement on the posttest of students who participated in the MME section of the course and the students who participated in the lecture-based section of the course, $F(1, 12) = 0.09$, $p = .77$ (see Table 4.5).

Table 4.5 Results Obtained from Analysis of Covariance for Posttest

Source	Sum-of-Squares	*df*	Mean-Square	*F*	*p*
Pretest	381.22	1	381.22	2.13	0.17
Between Groups	15.87	1	15.87	.09	0.77
Within Groups	2146.24	12	178.85		

Research Question 3

A survey was given to determine student satisfaction between the multimedia-enhanced section and the traditional lecture-based section. An online survey was given to the students in the MME course section, and a pencil and paper survey was given to the students in the lecture-based course section (see Appendix E). The survey contained nine Likert-scale questions, and three open-ended questions. The survey response rate was low. Eight out of nine students from the lecture section and three out of seven students from the MME section responded to the survey. After receiving such a low response from the students in the MME section, the researcher contacted the students from the MME section with follow-up emails twice but did not receive any additional responses to the survey.

Descriptive data

In response to item one on the survey, "The course presented skills in a helpful sequence," students in the MME section strongly agreed (66.7%), and neither agreed nor disagreed (33.3%). Students in the lecture section strongly agreed (75%) and agreed (25%; See Figure 4.1).

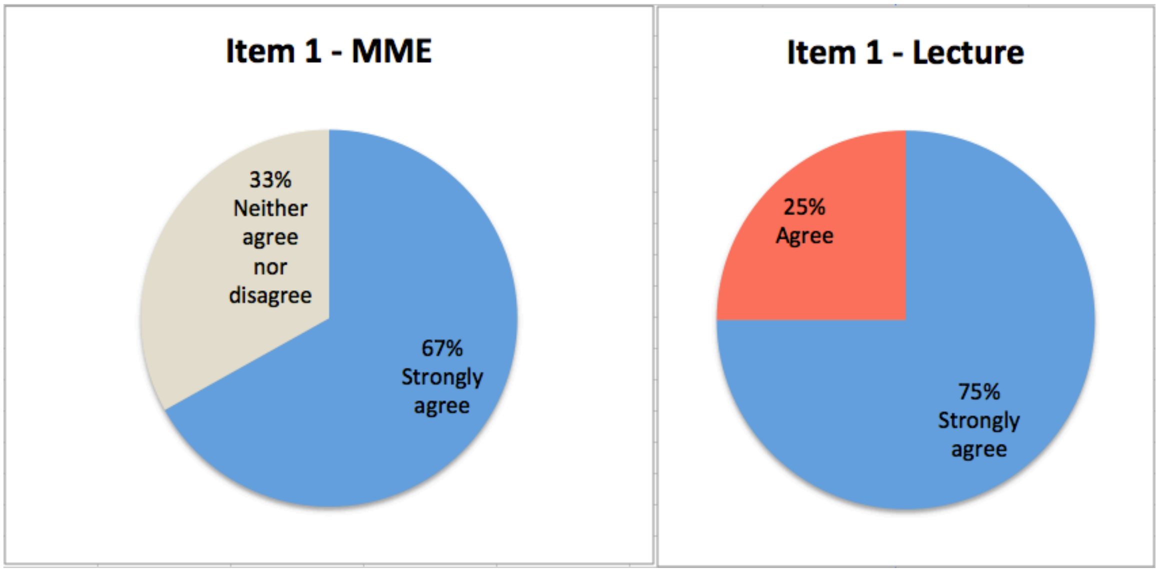


Figure 4.1 Responses to Item One: “The course presented skills in a helpful sequence.”

In response to item two on the survey, “The course provided an appropriate balance between instruction and practice,” students in the MME section strongly agreed (66.7%), and disagreed (33.3%). Students in the lecture section strongly agreed (75%) and agreed (25%; See Figure 4.2).

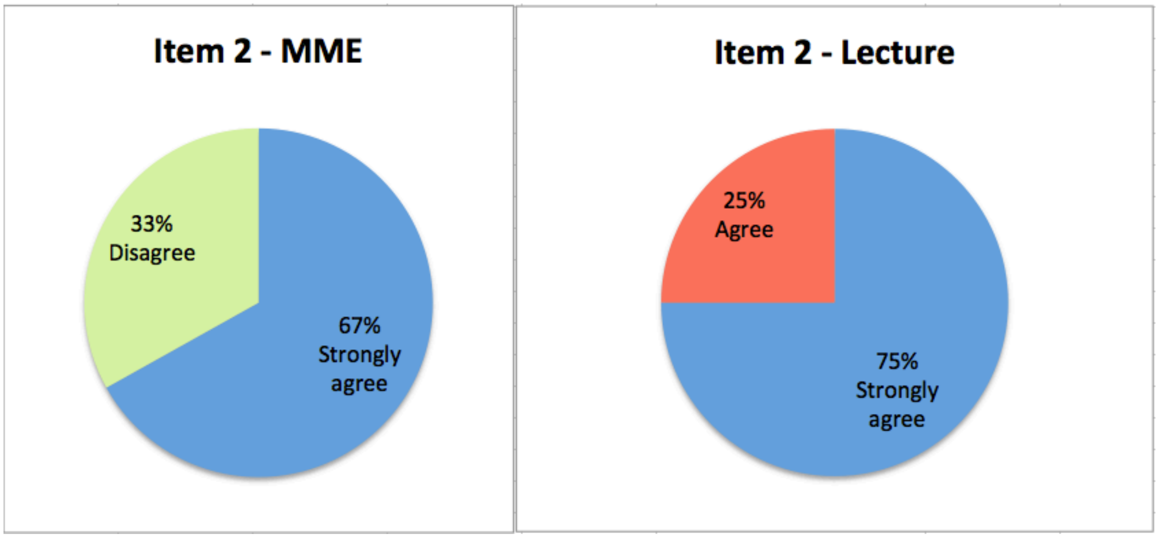


Figure 4.2 Responses to Item Two: “The course provided an appropriate balance between instruction and practice.”

In response to item three on the survey, “The course was appropriate for the stated level of the class,” students in the MME section strongly agreed (33%), agreed (33%), and disagreed (33%). Students in the lecture section strongly agreed (62.5%) and agreed (37.5%; See Figure 4.3).

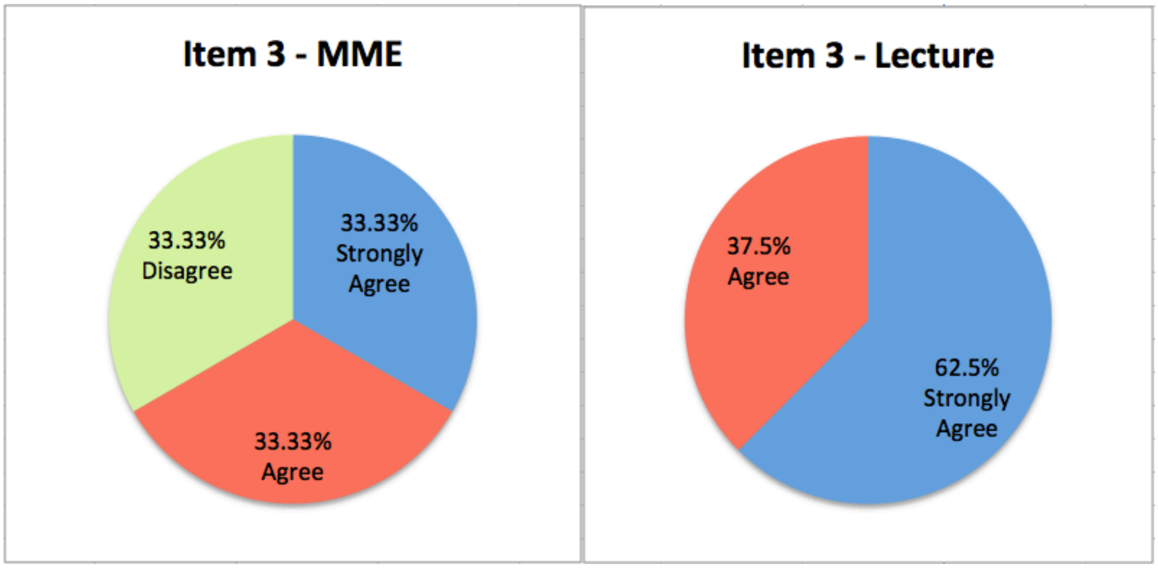


Figure 4.3 Responses to Item 3: “The course was appropriate for the stated level of the class”

In response to item four on the survey, “The course was organized in a way that helped me learn, students in the MME section strongly agreed (67%), and disagreed (33%). Students in the lecture section strongly agreed (75%) and agreed (25%; See Figure 4.4).

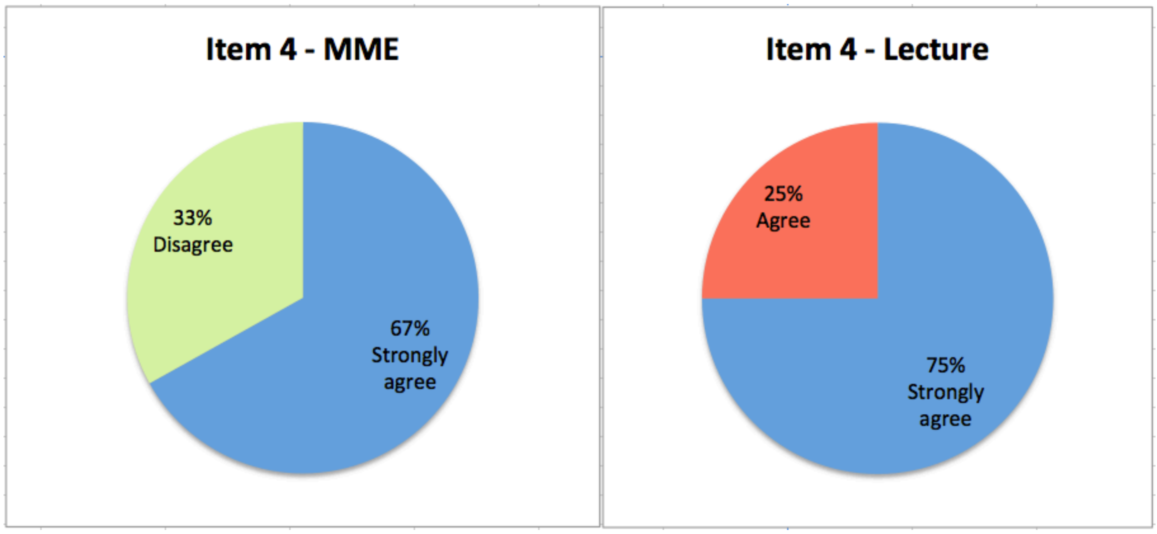


Figure 4.4 Responses to Item Four: “The course was organized in a way that helped me learn.”

In response to item five on the survey, “The course provided a mixture of explanation and practice,” students in the MME section strongly agreed (33%), agreed (33%), and neither agreed nor disagreed (33%). Students in the lecture section strongly agreed (75%) and agreed (25%; See Figure 4.5).

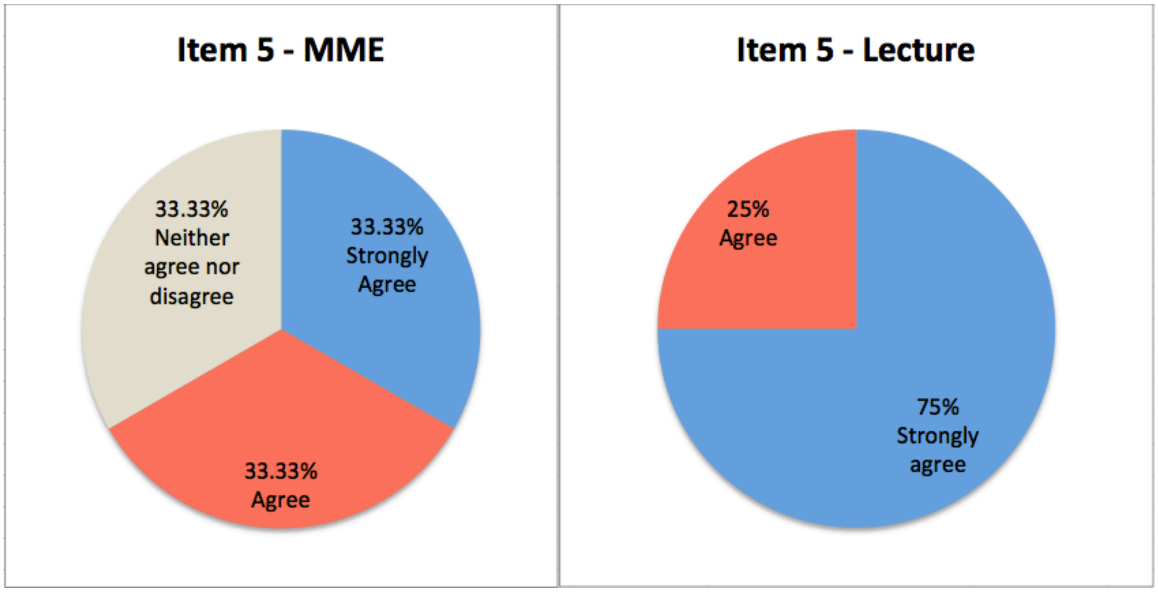


Figure 4.5 Responses to Item Five: “The course provided a mixture of explanation and practice.”

In response to item 6 on the survey, “The course was effectively organized,” 67% of the students in the MME section strongly agreed, and 33% agreed, while 75% of the students in the lecture section strongly agreed, and 25% agreed (See Figure 4.6).

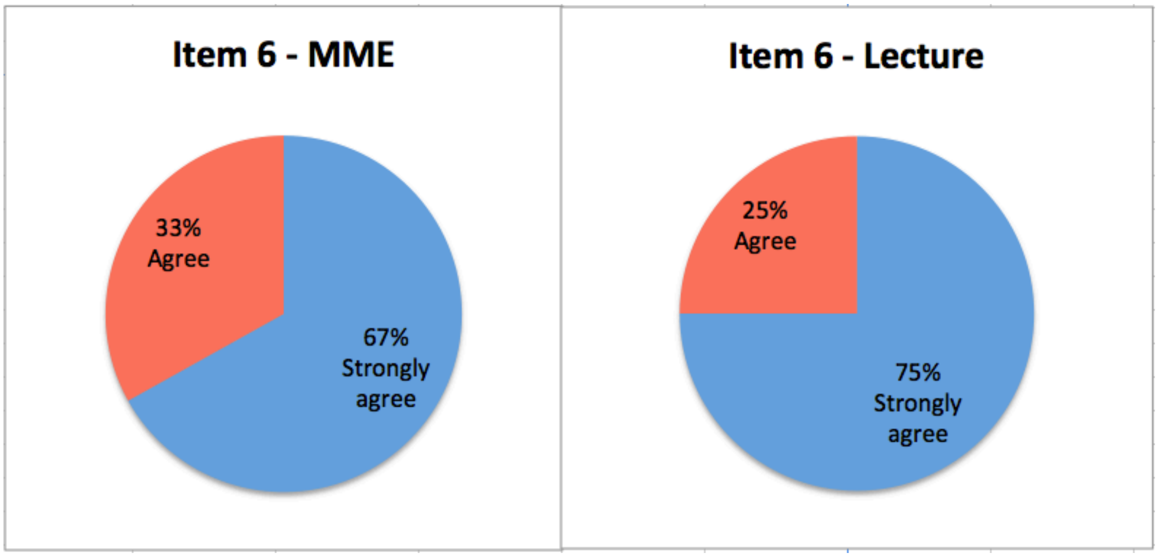


Figure 4.6 Responses to Item Six, "The course was effectively organized."

In response to item 7 on the survey, "The course assignments and lectures usefully complemented each other," 33% of the students in the MME section strongly agreed, 33% agreed, and 33.3% disagreed, while 75% of the students in the lecture section strongly agreed, and 25% agreed (See Figure 4.7).

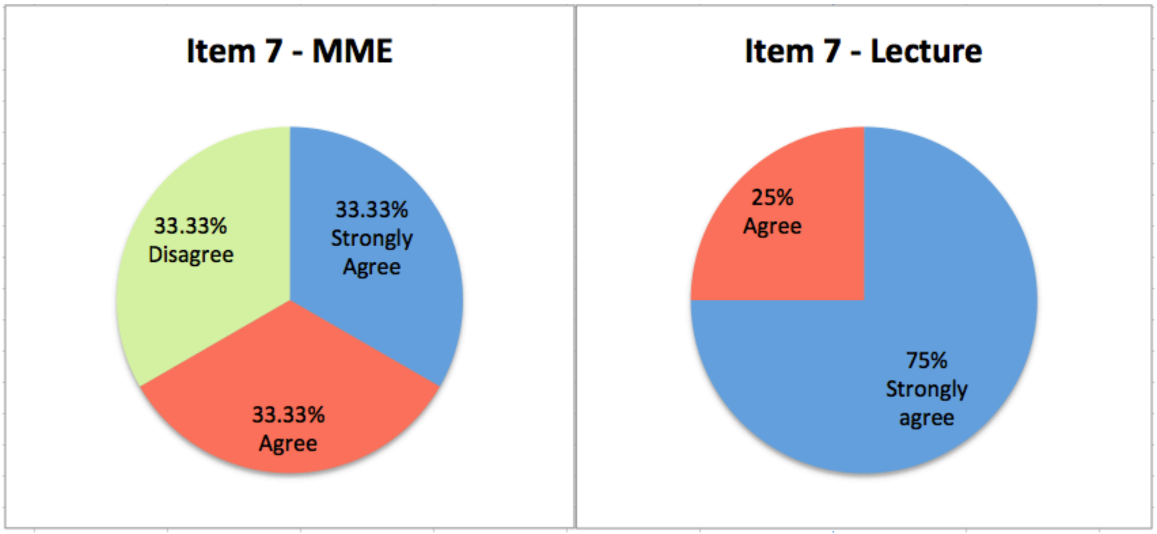


Figure 4.7 Responses to Item 7, “The course assignments and lectures usefully complemented each other”

In response to item 8 on the survey, “The course instructions (including, manuals, handouts, etc.) were clear,” 33% of the students in the MME section strongly agreed, 33% agreed, and 33.3% disagreed, while 75% of the students in the lecture section strongly agreed, and 25% agreed (See Figure 4.8).

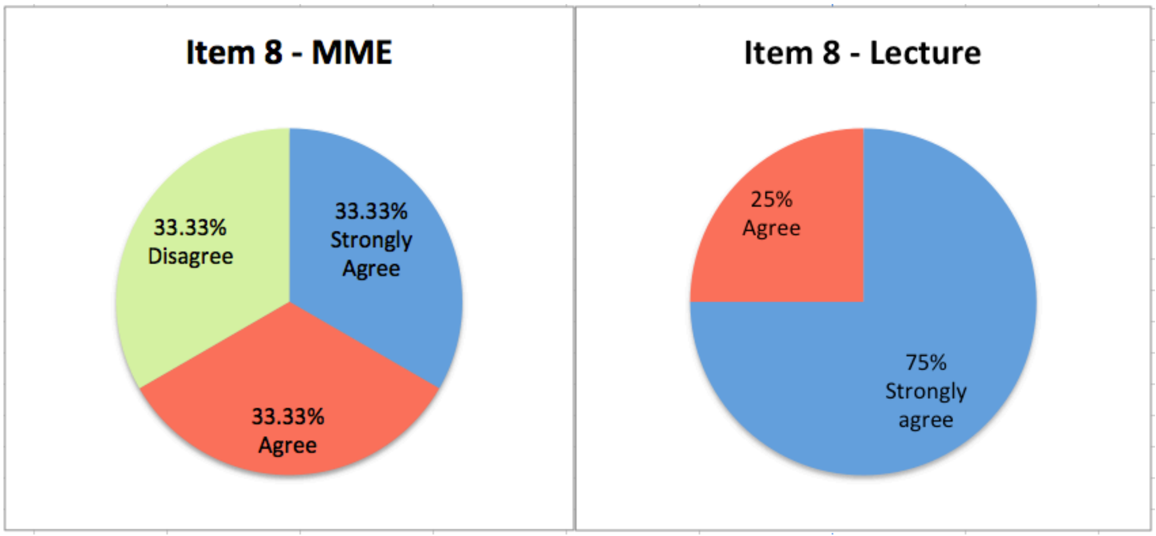


Figure 4.8 Responses to Item 8, "The course instructions (including, manuals, handouts, etc.) were clear."

In response to item 9 on the survey, "The coursework helped me understand concepts more clearly," 33% of the students in the MME section strongly agreed, 33% agreed, and 33.3% disagreed, while 75% of the students in the lecture section strongly agreed, and 25% agreed (See Figure 4.9).

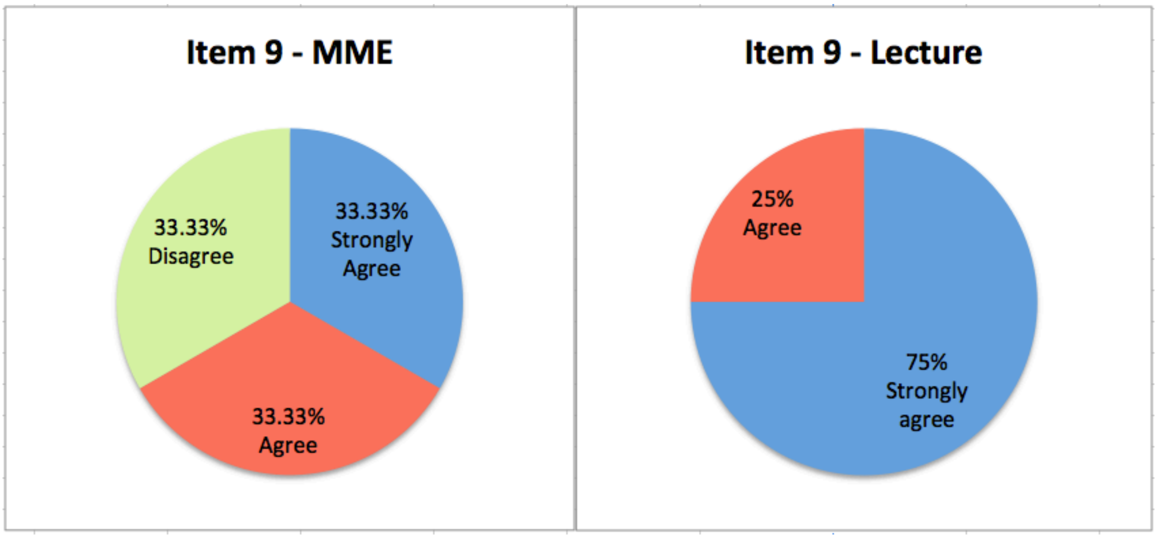


Figure 4.9 Responses to Item 9, "The coursework helped me understand concepts more clearly."

In response to item 10 on the survey, "Instructions for course materials (including manuals, handouts, etc.) were clear," 33% of the students in the MME section strongly agreed, 33% agreed, and 33.3% disagreed, while 75% of the students in the lecture section strongly agreed, and 25% agreed (See Figure 4.10).

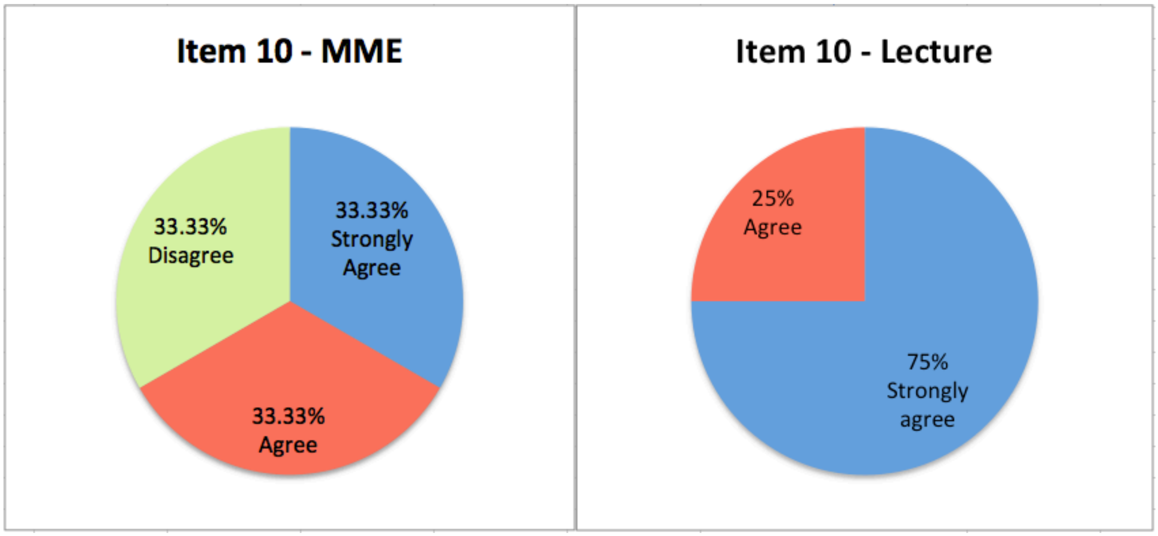


Figure 4.10 Responses to Item 10, "Instructions for course materials (including manuals, handouts, etc.) were clear."

Analyses

An analysis of variance test was conducted to determine if there was a significant difference in student satisfaction between the MME course and the lecture-based course. There was not a statistically significant difference between the satisfaction of students who participated in the MME section of the course and the students who participated in the lecture-based section of the course. As shown in Table 4.6, the Analysis of Variance test yielded an *F*-ratio of 2.80, and a *p* value of .129.

Table 4.6 Results Obtained from Analysis of Variance for Survey of Student Satisfaction

Source	Sum-of-Squares	*df*	Mean-Square	*F*	*p*
Group	153.03	1	153.03	2.80	0.129
Error	491.88	9	54.65		

QUALITATIVE RESULTS

Research Question 4

Interview analyses

After the interviews were transcribed by the researcher, they were analyzed to gather preliminary codes for further analysis. Codes were generated from the respondents' phrases from the transcribed interviews. A coding sheet was generated so that objective coding could be done to establish inter-rater reliability (IRR; see Tables 4.7 and 4.8). Similar codes were collapsed so that interrater coding could be done more efficiently (Creswell, 2015; Wilkinson & Birmingham, 2003). For example, P14 was collapsed from four similar codes: (a) making friends in class / I like the classmates, students helping each other in class; help over the phone, and meet with students at each others' houses. This code was collapsed to capture the different phrases the participants used to describe getting help from other students in the class. The second code that was collapsed was P2, which was collapsed from: environment conducive to getting work done, and concentration. This code was collapsed because the students' responses were very similar in that one student stated that the lab environment helped her to get work done and another student described being able to concentrate better in the lab. The codes for being able to concentrate and environment conducive to getting work done were both similar enough that the code was collapsed into one. The third code that was collapsed was N4: lack of application and why are we doing this. This code was collapsed because the students were describing the same concept of not understanding why learning the mathematics was necessary for their lives, but they each used different phrases. The fourth code that was collapsed was N12: not enough time, too fast, and need to slow down. The reason this code was collapsed was because the participant's comment about not having enough time, the course progressing too swiftly, and needing to slow down were similar enough that the researcher determined the participants were speaking about the same concept. The fifth code that was collapsed was T3: phone, laptop, and tablet. This code was collapsed as all three devices were used outside of the class to access the course material or the supplementary videos. Which device the participant used was a matter of preference and the researcher determined that the difference in devices used did not matter for the purpose of the research questions. The last code that was collapsed was T12, which listed different ways students could use the printers in the lab. Instead of having those as separate codes, the researcher bundled them together as T12.

Table 4.7 Coding Sheet: Part 1

Positive	
P2	Environment conducive to getting work done; concentration
P4	Preference
P5	Describing or talking about lab software
P6	Steps (How-to); step-by-step
P8	Formulas
P9	Examples
P10	Practice / repetition
P11	Understanding
P12	Use math for finance / money; personal reason to use math
P13	Satisfied with grade/progress
P14	Making friends in class / I like the classmates; Students helping each other in class; help over the phone; meet with students at each others' houses
P18	Positive feelings about teacher, an understanding teacher
P19	Having a goal for learning the math; goal or plan for future
P20	Know what to expect of teacher; teacher's routine
P21	Teacher gives good examples
P26	Work at own pace
Negative	
N1	Boring
N2	Lack of understanding
N3	Foreign language / confusing
N4	Lack of application / Why are we doing this
N6	Letters in math (reference to algebra)
N9	Don’t like math, hate math
N10	Class is too short (summer session)
N11	Feeling bad
N12	Not enough time / too fast /need to slow down

Table 4.8 Coding Sheet: Part 2

Past Experiences with Mathematics	
E1	Trouble with math
E2	Easy before algebra
E3	Easy in elementary
E4	Rote learning (times tables, for example)
E5	Bad teacher
E6	Afraid to ask for help
E7	Shy
E8	Loved math when younger
E9	Good teacher
E10	Didn't understand key terms
E11	Haven't done math in a long, long time
Technology	
T1	Portability
T2	Search function / Google / looking up help
T3	Phone; laptop or tablet
T5	Calculator
T7	Satisfied with own level of technology
T8	Prefer computer over textbook
T9	Audio
T10	YouTube or videos; access technology outside of class
T12	Use printers to print material, or any of the following:
	Print material at home
	Use of printed paper to work on course
	Print formulas
	Print step-by-step (guide)
	Print review

Member checks

The first step in the member check process occurred during the interview process. When the interview answered an open-ended question, the researcher paraphrased or summarized what had been said, as a means to confirm the participant's intended meaning. Following the interview, the researcher provided the interviewee with a written report of the interview, so confirmation, correction, and clarification could be provided. None of the interviewees returned the transcripts with corrections, so no clarifications were made to the transcripts.

Interrater reliability

Two Ph.D. graduates from The University of Texas at Austin independently and separately coded three randomly selected interview transcripts. There were a total of 87 codes from the three interviews. Interrater reliability (IRR) was established at 77% with the first coder, with agreement of 67 out of 87 codes. IRR was established at 69% with the second coder, with agreement of 60 out of 87 codes.

Qualitative themes

Transcripts from participant interviews were coded and analyzed for themes. Upon this analysis, eight qualitative themes emerged (see Figure 4.11). The eight themes were: (a) computer lab factors, (b) technology, (c) things that are important in learning mathematics, (d) collaboration, (e) teacher, (f) negative feelings about mathematics, (g) past experiences with mathematics, and (h) barriers. These themes were helpful in answering research questions four and five, and in creating the list of facilitators of learning in the MME course (see Table 4.9).

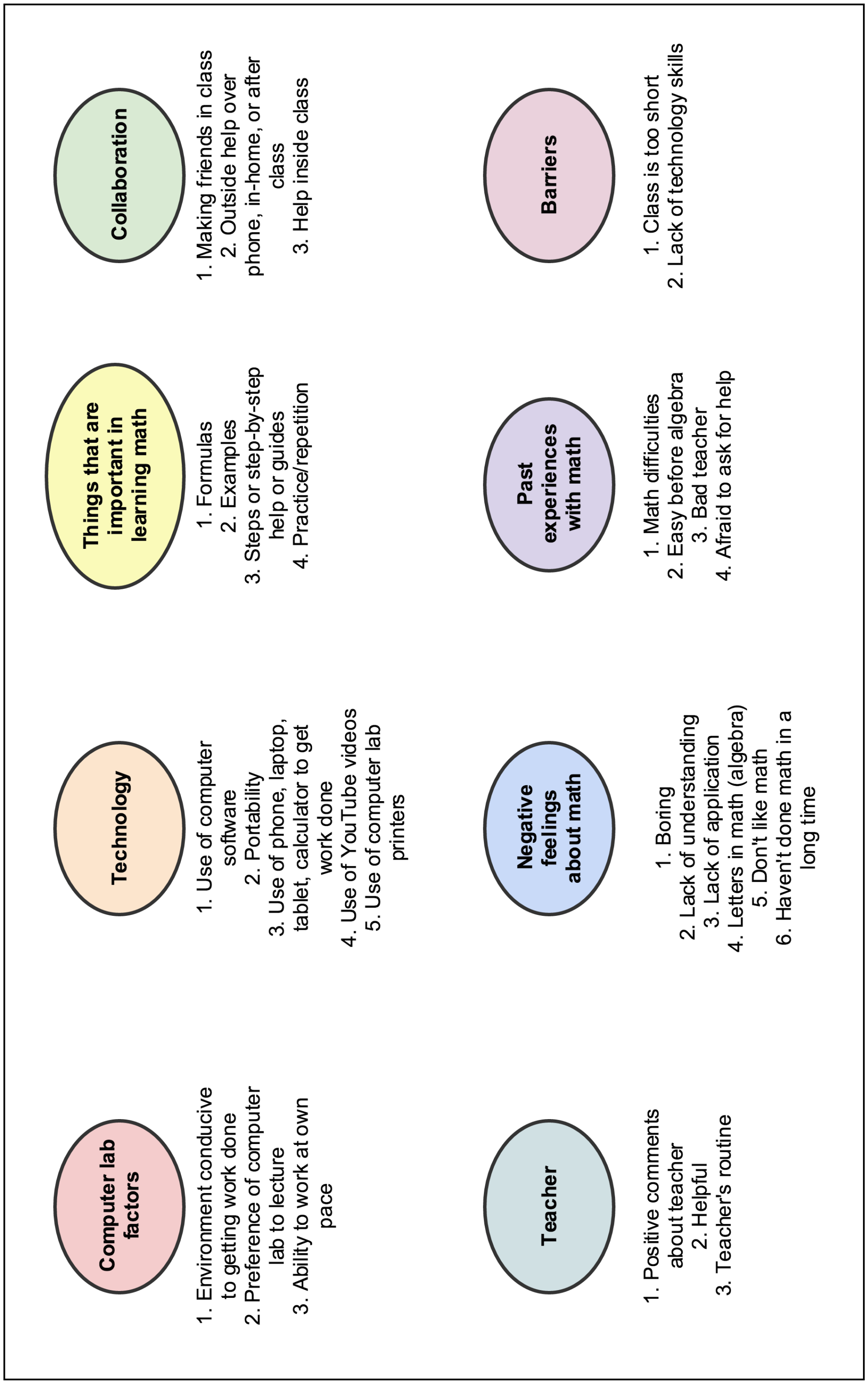


Figure 4.11 Qualitative Themes

Barriers to learning in the multimedia-enhanced course

Length of session

Students in the MME course mentioned two barriers to their learning. The first barrier was the length of the course. The MME section lasted 5 weeks. One student in the MME course said, “The only thing I don’t like is that it’s only a five week thing, versus if it was longer, it gives you more time, especially cause I work, and have kids, and ugh.”

Lack of technology skills

The second barrier to learning in the MME course was lack of technology skills. However, only one student mentioned this as a problem. She stated that she would like to have better technology skills: “I’m not great at technology, but I think I know enough to get by. It would be nice if I knew a little bit more…”

Barriers to learning in the lecture-based course

Students in the lecture section described the length of course as a barrier to learning. One student stated, “It’s rushed through the summer.” Another student expressed worry over passing the course because it was so short: “Because this is an extremely short class so we had to learn it quickly. So now I’m kind of iffy on passing his final cause it’s still a lot of things I don’t understand, I don’t get.” A third student described feeling rushed through the class: “you have to cram everything in, more, in a shorter time”

Facilitators of learning in the multimedia-enhanced course

Although the students only mentioned two barriers to learning in the MME course, they described 11 facilitators of learning (see Table 4.9). All of the students that were interviewed in the MME section (100%) described four facilitators: (a) helpful instructor, (b) supplementary videos provided by faculty member, (c) collaboration with peers, and (d) examples in the software showing how to work the problems. Some of the facilitators to learning in the MME section were also facilitators to learning in the lecture section.

Table 4.9 Facilitators of Learning in the MME Course

Facilitator	**Percentage of Students in MME Course**
Helpful instructor	100%
Supplementary videos	100%
Collaboration with peers	100%
Examples in software	100%
Step-by-step instructions	75%
Portability of the course	75%
Print	75%
Work in the lab	50%
Work at own pace	50%
Online textbook	50%
Practice opportunities	25%

Helpful instructor

All of the students thought that "Dr. Franco" was very helpful. One student described him as,

> …pretty nice. We ask him questions and he'll tell you, you know, exactly how, and while you're doing it, so he'll give you a good example and I pretty much catch on when he, when I don't understand something and he'll explain. So I'll be like, "Oh okay now it makes sense." So I get it.

A second student said, "I feel like he is pretty open, he's approachable. I don't interact with him at all but he interacts with me." A third student appreciated the way that "Dr. Franco" explained things to her, "He, he explains it very well to where you can understand it, I just need to study it a little bit more to get uh, better understanding of how I need to come up with the points. But he explains it great." The fourth student said, "Good. He's very good. He helps us a lot."

Supplementary videos provided by faculty member

All of the students in the MME section mentioned the importance of having the supplementary videos provided by "Dr. Bunch." These videos were embedded into the MyMathLab software and more could be accessed via YouTube. Some of the students' comments were as follows:

> "Oh yeah, I have my computer at home, I have a laptop, and an iPad, and I'm always going like the YouTube app, the guy that, I don't know what his name was."

> "Well, uh, well, I have learned a lot because like I said, it has videos. The videos, the examples, that and if you don't know it, it's good that it gives you the option to like, gives you three options, you know, yeah, but it gives you keep on trying,

keep looking, it gives you where you can actually go back and study more, so you know, it's very good."

"I actually don't do work outside of class unless there is, like a test, and that's when I use the YouTube, I'll use it a lot."

"Yes. He gave us that.["Dr. Bunch's" videos] I've been using those too, to get info."

"Yeah, I've gone on to the YouTube, and I've been watching the step-by-step for the reviews and we have the quizzes, so that helped me. I made an 88 on the last test."

Collaboration with peers

Collaboration with peers was the third facilitator that all four students in the MME section mentioned in the interviews. These students discussed how they collaborated with other students in the class, as well as after the class in tutorials, and over the phone.

One student discussed her interaction with others in the class, and compared it to being in a "normal" class: "Um, we talk if we get stuck on a problem or something. We might nudge each other (unintelligible) so pretty much the same as the normal classroom." Another student mentioned getting help from other students in the class: "Um, actually, I have made some new friends, and we all discuss, you know, how we feel, and we help each other out. One person might get something, and the other person doesn't. Everybody has their strengths and weaknesses, and we just play off of that."

A third student described how sometimes help from the other students is better than getting help from the teacher:

> When you're in a group, you can always ask people if they know it and if they can explain it to you. And sometimes you can understand better when it's coming from somebody else than the teacher. So sometimes he's helpful, or sometimes he'll explain it and if you still don't get it, you can ask somebody that actually gets it and sometimes two people explaining it differently can help you. So that's the thing about it, you get more help here than doing it by yourself.

Examples in the software showing how to work the problems

The fourth facilitator of learning that all four students who were interviewed in the MME section mentioned was the provision of examples by the MyMathLab software. The students described using the examples provided to help them figure out how to work the mathematics problems. One student stated, "I know that there's an example for every question and that really helps me understand what I'm doing." Another student talked about printing examples, charts, and diagrams: "He has a bunch of like examples on the MyMathLab where um, like charts and diagrams and stuff like that, notes and stuff in there so that's what we print out."

A third student compared the MME course to a mathematics course she had taken previously, and listed examples, videos and scenarios when describing what she liked about this course: “It’s very informative. Actually I’ve taken a math class before, with, that’s not, that’s not computer based, so I really like the computer based. It gives us a chance, is able to look at examples and videos and scenarios, and so I like it. So it’s very informative.”

The fourth student mentioned the examples as one of the various options offered by the software:

> Well, what helps me is that they give you examples and then plus, if you don’t get it, it gives you like the videos, and if you still don’t get it they give you like a helping guide, they go you step-by-step. And that’s what I like. That there’s always options.

Three out of the four students interviewed in the MME section (75%) described three other facilitators of learning: (a) step-by-step instructions in the software, (b) portability of the course, and (c) the ability to print the necessary information from the software.

Step-by-step instructions

Three students in the MME section mentioned the importance of having step-by-step instructions. One of the students discussed how the computer gave step-by-step instructions, in comparison to using solely a textbook:

> Yeah, I prefer to do it on the computer, and it shows all the steps, and it’s helpful, so….you know, you can have all this information on the computer and everything

is there…it tells step by step directions how to do things, so that's very helpful, than to just be reading a textbook.

Portability of the course

Three students in the MME section also discussed the benefits of the portability and accessibility of the course outside of the physical classroom. This is one facilitator that the students in the lecture section did not have. One student stated, "If I want to do it from home, I can do it from home, no problem." Another student said, "So it's like you can do it from anywhere, so if you're not doing anything at home you can just log in to it. It's the same thing you're doing here. So I like it." The third student described the portability of the course in terms of being able to access it from anywhere: "I pretty much can take it with me wherever I go, so I mean, I have my laptop with me all the time, and I'm able to look up anything and everything I need, so I love it."

Ability to print the necessary information from the software

Three students in the MME section mentioned printing the course materials from the software. This is another facilitator that the students in the lecture section did not have. Students used the in-class printers to print homework problems, charts and formulas, and reviews for the tests. One student printed out problems to work by hand or at home, and then went back to the computer to input her answers. She said, "Sometimes I print out the homework and I take them at home, or at work, and you're able to go over them and input it back in. So I do that."

Another student only printed out the review for the test, saying, "The only thing that I print out was the review. That's the only thing. Yes. Only for the test. Which I

…make a copy of it, and just work it." The third student used the printer for several different purposes:

> He has a bunch of like examples on the MML where um, like charts and diagrams and stuff like that, notes and stuff in there so that's what we print out… So I have a bunch of stuff that I've printed out that explains to you like the terminology of you know certain words and so it's pretty cool …. Um, I printed out like all the different formulas and the different steps for the different problems so that I can review it while I'm doing my homework for whatever quiz we might have coming up.

Two out of the four students interviewed in the MME section (50%) described three more facilitators of learning: (a) being able to work in the lab, (b) ability to work at own pace, and (c) having direct access to the textbook online. The last facilitator of learning that one student out of the four mentioned was ample opportunities for practice.

Being able to work in the lab

One student worked from home, so she enjoyed being able to come to work in the computer lab: "I like it in the lab, cause I'm already at home for work, so I don't wanna be at, that's too much." The other student liked working in the computer lab because it helped her to concentrate better: "It helps me because I need to be in this type of environment, because if I'm off on my own I'm not gonna be able to concentrate and so yeah (laugh)...Um, I like working in the lab cause I don't get nothing done at home."

Ability to work at own pace

Two of the students also discussed being able to work at their own pace. One student said:

> You do as much as you can until you're stuck. And then once you're stuck you can just ask the teacher and he'll help you, versus going to class, and going step-by-step the way the teacher wants you to go. You know, maybe you're advanced, or maybe you're too slow…I like that everybody works at their own pace and um like I said, you don't have to be at a certain level like everybody else. Everybody's different.

Similarly, the other student said:

> Well you get to work on your own pace and you have deadlines so that's pretty cool, cause you know what you need to do. So, he gives you everything ahead of time and you have your deadline so if you need to study, if you make time for it, you should be fine. I mean, its pretty basic. Everything is online, it's at your own pace but you have deadlines at the same time. It does explain to you but if you don't understand something you're gonna have to ask questions. Cause he can't help you if you don't ask.

Ample opportunities for practice

One student out of the four who were interviewed mentioned that the MyMathLab software provided plenty of practice opportunities: "I really like it. This is my first time using it, and I like the fact that it gives you a chance to you know, practice, and understand what you're doing. So I really like that."

Facilitators of learning in the lecture-based course

Table 4.10 lists the facilitators of learning described by students who were interviewed in the lecture-based course. The students mentioned four facilitators of learning: (a) helpful instructor, (b) supplementary videos, (c) collaboration with peers, and (d) practice opportunities.

Table 4.10 Facilitators of Learning in the Lecture-Based Course

Facilitator	**Percentage of Students in Lecture-Based Course**
Helpful instructor	100%
Supplementary videos	100%
Collaboration with peers	100%
Practice opportunities	50%

Helpful instructor

All of the students in the lecture section described "Dr. Bunch" as helpful, as well. One student said:

> He explains it very well to where you can understand it... The way he puts it down and he helps you, uh, he helps you understand, you know, the function of the problem. That's what I like about his class. I mean he helps you down to the end of it.

Another student said:

> It's like when he sits and he teaches and explain it to us, I understand… when he actually break it down and puts it on the board, it's more easier to understand when he actually break it down and explain it to us... I like the way he teaches… he's a great math teacher… he is extremely easy to understand.

A third student said:

> I like first of all, I like his approach. I like the way, you know, he almost reads you, as if you, he's explaining it, and you're not getting it, he stops and say, "Well, what's the problem?" He makes you talk through the issue. It's like, and then you, and to realize, oh yeah, it really is an issue.

Supplementary videos provided by faculty member

All of the students in the lecture session mentioned the importance of having the supplementary videos on YouTube provided by "Dr. Bunch." One student said, "And then his videos helps too. That he has on YouTube. You just go home and watch, you know, what you learned in class." Another student from the lecture section used the videos as well: "We get on the Internet and watch the videos… I watch the videos, at home. Um, and just really just try to, you know, try to keep it fresh on my brain at home so I can remember the steps." A third student said, "I use his videos cause I have to when I'm at home."

Collaboration with peers

Collaboration with peers was not unique to the MME section of the course. All four of the students in the lecture section who were interviewed also discussed their collaboration with peers. These students met after class for a tutoring session, talked on the phone, and even met at each other's houses. One of the students who described these interactions said:

> I either we'll be on the phone, and we'll kind of go through the problem, but it's easier when you're together. Uh, one of the students came to my house and it helped me while I was helping her, explain the problem, and I was figuring out what I was doing wrong, and I showed her. This is what I did wrong. So it helped me focus on, when I'm working a problem out, to make sure to look at the signs.

Ample opportunities for practice

Two students in the lecture section mentioned the importance of practice and repetition as well. One student said:

> I'm a very hands-on learner. So like I said, I would. I need…need a teacher to come and break it down piece by piece and then me working the, not the same problem, but just the problem with different numbers. Same problem in different ways... Yeah, practicing the same thing over and over so I can get it. The repetition. In my head.

Summary of barriers and facilitators

In summary, there were two barriers to learning in the MME course, and 11 facilitators. In the lecture-based course, students mentioned one barrier and four facilitators. Five of the students interviewed from both sections felt that the course was too short. Only one student from the MME course felt that she wished she had better technology skills, but also stated that she was "doing okay." In contrast to only two barriers mentioned, there were 11 facilitators, or factors that helped the students learn mathematics in the MME course section. Of those 11, four were also mentioned in the lecture-based section: (a) helpful instructor, (b) supplementary videos, (c) collaboration with peers, and (d) practice.

Research Question 5

Past experiences with mathematics

Students who were interviewed were asked to discuss past experiences with mathematics. Two themes emerged from this discussion: students described previous mathematics teachers who were bad, and students described a LD or math difficulties (See Table 4.11).

Table 4.11 Students' Past Experiences with Mathematics and Dispositions Towards Mathematics Learning in General

	Percentage of Students in MME Section	Percentage of Students in Lecture-Based section
Bad Teacher	50%	100%
LD	0%	25%
Mathematics Difficulties	100%	100%
Negative Feelings about Mathematics	100%	100%
Lack of Application	50%	25%
Haven't Done Mathematics in a Long Time	50%	50%

Bad teacher

Two of the students from the MME section and all of the students from the lecture-based section discussed having difficulties in the past and having bad experiences with a teacher, or being afraid to ask for help when they needed it. One student said, "I just couldn't ever make sense of it, and I never really had a teacher who ever took the time to break it down to where I could understand it." A second student recounted a time when a teacher did not teach her the mathematics:

> It was mostly high school cause uh um I had a math teacher – I failed and I actually had to come to HCC to uh take the credit for it. Cause the teacher we had at the time was kind of like, book, do it your own, no lecture kind of deal, so I ended up failing that part of the math, and I ended up having to come here in order for me not to, cause I didn't want to be sent back and not graduate.

A third student described a similar experience with a teacher in high school. She described her feelings of frustration to the point of giving up and withdrawing from even trying to learn the mathematics:

> I do remember a teacher I had. And he just wasn't he wasn't a type of teacher that explained it thoroughly to where you can understand. So when you don't understand something, you get frustrated. And when you're not getting' uh, someone to explain it to you, the way that you need, then you just kind of push it, push it, push it away.

After the student made the above comment, I asked her, "And that caused you to sort of withdraw from math?" She replied, "Exactly. That, this was my biggest fear comin' in here, because I felt like, it wasn't uh, I'm not gonna get it. And now that I look back on it, it's because of the instructor."

Another student described being afraid to ask for help: "It's hard to ask a question when you don't know the answer, even when, especially when you're shy. Cause you almost feel miserable." Six out of the eight students that were interviewed had a negative past experience with a mathematics teacher.

LD and mathematics difficulties

As mentioned in the Participants section, only one person self-identified as having LD. The student with LD stated that her math difficulties began her junior year in high school. She said:

> The beginning of my junior year it start to get difficult, cause it start to get harder and harder… as you keep growing and getting older, going to a different grade, different levels, it gets hard. So my junior year is when, junior year is when you start to learn like, the, uh, the graphs, and things like that.

She further described her difficulties and how she got one-on-one help from a teacher to help her solve her mathematics problems:

> It was getting kind of difficult. Cause me going, just looking at the board with the teacher, I don't understand it, so I have to have my teachers come to me, actually solve my, help me to solve my problems, cause I have a learning disability. So, so I catch on slower than others. And it was kind of getting difficult for me. It was getting really difficult, so I had – teachers actually had to come to my desk and help me solve it, and I understood my problems.

However, not all of her teachers were helpful. She described having problems with a teaching in the past:

> Yeah well I had this one teacher. I just didn't really understood how he taught. It was very difficult for me. And then he was a difficult teacher to deal with, too, because we would ask him, and then he was like, he'll be like, I already explain it.

> But I didn’t understand how you explained it. So it was very difficult dealing with that teacher.

Although she had a bad experience with that teacher, she described having a good experience with the instructor of the lecture-based section, “Dr. Bunch.” She described getting help from him and being able to understand the mathematics when the he was helping her, but then having more difficulty when she was at home trying to do the homework on her own:

> Um, he have different ways to um solving the problem, getting the same answer, and so it’s like, how do you remember all of this? But it’s like when he sits and he teaches and explain it to us, I understand. But when you get home it gets difficult. So it’s like , it’s like, I don’t understand it. But when he actually break it down and puts it on the board, it’s more easier to understand when he actually break it down and explain it to us.

For this student, one of the difficulties she described was when a teacher would give her several ways to do the problem. She expressed that it would be better for her to only have one way to solve the problem: “Sometimes when you’re doing the same problem, but doing it a different way to get the answer, I get confused. It’s like, it’s confusing… I just like to know that one way, you know, and learning like a million ways is kind of difficult to understand.”

When asked what kind of help she needed in the mathematics course, she said:

> I'm a very hands-on learner. So like I said, I would. I need, I just can't think of everything from my head. Um, I use my fingers to do my math. Um, or I use my little sticks on paper, um, and just like, need a teacher to come and break it down piece by piece and then me working the, not the same problem, but just the problem with different numbers—same problem in different ways.

When asked how she used technology to help her in her schoolwork, she said:

> We have like my phone, I can flip my phone to the side, and it can be a scientific calculator. But it doesn't have everything that a regular scientific calculator has but it has a lot of things that can help. Um, Internet. It can look up on how to solve a problem. When I have time I try to watch his videos.

She also described getting help from the people in her community at her church:

> A lot of people inside my church, um, they're teachers. A lot of them teach math. A lot of them doctors, so it's kind of a benefit for me too, cause when I need help, I can just go to them and ask them, you know, so I know plenty of teachers at my church, like I know three of them at my church, that, you know, that teach math. Sometimes when I can, like I spend a whole—one of them, she's my sister's best friend, so I spent a whole week at her house for her helping me. It was while I was in this class, she was helping me with my work. And she was teaching me studying techniques, things like that.

All of the students that were interviewed described having mathematics difficulties and mentioned that they struggled with mathematics in high school. Students described feelings of boredom with mathematics, not understanding key terms, not being able to make sense of the material, and falling further behind in mathematics throughout the years. Several students made the comment that mathematics started becoming incomprehensible to them once algebra was introduced, and one student mentioned, "I don't like the fact that we work with letters." Another student said, "When it changed from numbers to letters, that's when it became a problem…I fell behind… I was struggling."

Some of the students in the MME section described their difficulty with mathematics in general. One student said, "Sometimes it can be complicated to me. I'm not a math person…math is not an easy subject for me." Similarly, another student said, "I really don't like it. Cause I uh, I'm not that good at it. But that doesn't mean that I'm not gonna try it." One student in the lecture-based section made a similar comment, stating, "Well, for me, math has always been a touchy subject. I've always hated it, dreaded it, because I never, never understood it." A second student in the lecture-based section said, "Before I got in here, before I started taking math, I said, 'I am horrible at math.' Literally, I'm horrible. I already said that in my head." Even though only one student reported having a LD, all of the students had mathematics difficulties.

Negative feelings about mathematics

Because of their past experiences with mathematics, all of the students had negative feelings about mathematics. All of the students that were interviewed described feelings of having difficulty with mathematics and therefore had negative feelings about mathematics. All of the students did not like mathematics. They reported a lack of understanding why mathematics was necessary for them. Also, several of the students from both sections said that they had not done any mathematics in a really long time.

Lack of application

Two students from the MME section and one student from the lecture-based section discussed their feelings of not understanding why they needed to learn mathematics. One student from the MME section stated, “I’m just like, ok what is this? What am I using it for? Why are we doing this? So that’s where it hits home for me.” The second student from the MME section said, “Some of the stuff we don’t need in our careers or the things that we do.” Similarly, the student from the lecture-based section said, “Sometimes, like, I’ve asked Professor Bunch – I was like, at the end of the day, when in every day life are we really gonna use all the x’s and o’s? Because at the end of the day, it’s still numbers.”

Have not done mathematics in a long time

Another factor influencing the students’ negative feelings about mathematics was that some of them had not done mathematics in a long time. Two students from the MME section and two students from the lecture-based section discussed this in their interviews.

One student from the MME section said that she did not remember her past mathematics classes because it was so long ago. She stated, “My classes, no I don't. I actually got married at 15, so I really didn’t do much at all.” When asked to elaborate, she said, “In the past? I don’t remember…that was a long time ago.”

The second student from the MME section said, “Well see, it’s been so long, cause I’m 32 now. So me, doing all this, like algebra, back in high school, um… math is not my strongest subject at all.”

Likewise, one student from the lecture-based section said, “I can’t remember. That was so long ago…20 years! Over 20 years!” The second student from the lecture-based section said,

> I haven’t touched it since 1995… You know, okay, that’s the last time I’ve done any type of math like this. 1995… you have some that may get it, especially if they just did it last semester. And then you have others who, like myself, that haven’t touched it in over ten years or longer.

Summary of Qualitative Themes

In summary, the qualitative themes that emerged included the barriers and facilitators to learning that were addressed in section Research Question 4, as well as negative feelings about mathematics and past experiences with mathematics that were addressed in section Research Question 5. All of the students who were interviewed had bad experiences with mathematics in high school, and subsequently had negative feelings about mathematics. Several students described having difficulties with a mathematics teacher in high school, which impacted their success with mathematics and contributed to their struggles with mathematics.

Fidelity of Implementation for Treatment and Control Conditions

Fidelity of Implementation for the Treatment and Control conditions was conducted to for the MME course and the lecture-based course (see Appendix F). A total of 14 fidelity observations were conducted; six observations were conducted in the lecture-based section and eight were conducted in the MME section. More fidelity of treatment was conducted in the MME section than in the lecture-based section because in the beginning of the study, there were two MME sections: a 5-week and an 8-week section. However, the 8-week MME section stopped meeting after week four because one student finished early and three students dropped the course. After week four, there was only one MME section that met, and that was the five-week section. The results of the Fidelity of Implementation for the Treatment and Control conditions are located in Table 4.12 and Table 4.13.

Table 4.12 Fidelity of Treatment and Control Conditions

Items	Treatment times present	Treatment times total	Control times present	Control times total
Lecture	1	7	6	6
Small group	0	7	1	6
Technology	7	7	1	6
Opportunities for practice	7	7	3	6
One-on-one instruction	7	7	0	6
Monitoring progress	7	7	0	6

Table 4.13 Fidelity of Treatment Condition

Items	Times Present	Times Total
Instructor checks individual student progress on teacher computer	8	8
Instructor walks up and down through the lab, asking each student what they need help with.	7	8
Instructor gives one-on-one help in the back of the classroom	3	8
Instructor works with student at their computer	8	8
Instructor teaches to the whole class problems missed on most recent unit test	0	8
Instructor reviews the final exam problems and works problems in front of whole class	0	8

SUMMARY OF CHAPTER

In summary, there were no significant differences on the mathematics performance of the posttests and final exam between students enrolled in the lecture-based course and students enrolled in the MME course. Student interviews were conducted to determine the students' perceptions of barriers and facilitators to learning in the MME and lecture course conditions. The barriers included the short amount of time for the summer course and lack of technology skills. The facilitators included: (a) helpful instructor, (b) supplementary videos provided by faculty member, (c) collaboration with peers, (d) examples in the software showing how to work the problems, (e) step-by-step instructions, (f) portability of the course, (g) ability to print from the lab, (h) working in the lab, (i) working at own pace, (j) access to the textbook online, and (k) opportunities for practice. These results are discussed in further detail in Chapter 5 and implications for practice and further research are also considered.

Chapter 5: Discussion

The purpose of this study was fourfold. First, the purpose was to perform a comparative analysis on two modes of instruction of basic algebra. The second purpose was to determine the student levels of satisfaction between the lecture-based and MME course. The third purpose was to examine student perceptions of the barriers and facilitators of their learning in a multimedia-enhanced (MME) and a lecture-based course. The fourth purpose was to discover students' past experiences with mathematics and their dispositions towards learning mathematics in the MME and lecture-based course.

Performance on the Algebra Posttest and Final Exam

Research has been conducted to examine the use of computer-based instruction (CBI) to deliver the curriculum without an instructor present (Potocka, 2010; Taylor, 2008), and the use of technology to deliver partial instruction or homework (Kodippili & Senaratne, 2008; Spradlin & Ackerman, 2010; Stillson & Alsup, 2003). Taylor (2008) found that for some students, the lecture method was best, and for other students the computer-based instruction was best. Spradlin and Ackerman (2010) found no significant differences between a course that used traditional instruction and a course that used traditional instruction with supplementary computer-based instruction. These findings support the findings of this study, in that there were no significant differences of mathematics achievement between students enrolled in a lecture-based course and students enrolled in a MME course.

Another finding was that students in the MME course performed better on the final exam than on the posttest. The average final exam score for students in the MME course was 69.4, and the average posttest score was 56.4. This difference could be due to the fact that passing the final exam was a condition for the students to pass the course. Conversely, the posttest was voluntary; therefore, the students did not have incentive to perform well, as the score was not relevant to their grade in the course. Students in the lecture course performed similarly on the final exam as they did on the posttest, with average scores of 59.9 for the final exam and 58.8 for the posttest.

To date, no study has examined the differences in student performances on a posttest and final exam between a multimedia-enhanced course that used MyMathLab to deliver all of the instruction. In this setting, the MME condition featured two primary benefits that were available including supportive video instruction and an instructor who was always present to provide one-on-one instruction. In the traditional lecture-based condition the instructor taught the same curriculum and used the same assessment, without the use of computers to deliver instruction.

PERCEPTIONS OF BARRIERS AND FACILITATORS AND STUDENT SATISFACTION

Even though students discussed many benefits of the MME course, the results indicated that there were no significant differences in student performances on the posttest and final exam between the students in the MME course and the lecture-based course. Possible reasons for this could be: (a) students collaborated with peers in both sections, (b) the length of the MME course was shorter than the lecture-based course, and

(c) students in both sections accessed the supplementary videos on YouTube, as these were the highest reported facilitators in both conditions.

This study gathered data concerning the students' perceptions of the barriers and facilitators to their learning in a multimedia enhanced course. Many of the facilitators to learning in the MME course were also facilitators for students in the lecture-based course.

The Seven Principles of Good Practice in Undergraduate Education by Chickering and Gamson (1987) mentioned in Chapter 2 may shed light on some of the findings. The first principle mentioned was to encourage student-faculty contact. Students in both sections had access to the instructor, and the "helpful instruction" was one of the facilitators to learning in both conditions. Students from both sections found their professor to be helpful, and in the interviews mentioned positive things about both of the professors. Both professors had been using multimedia-enhanced instruction for 20 years, and had approximately 40 years of teaching experience each. As mentioned previously, both sections of the course had an instructor present, and attendance was mandatory. This study was unique in that the MME course was fully online, with mandatory attendance to the computer lab, and had an instructor to provide one-on-one instruction to the students. This finding is supported by the first principle of the "Seven Principles of Good Practice in Undergraduate Education" (Chickering & Gamson, 1987).

The second Principle of Good Practice (Chickering & Gamson, 1987) was to encourage cooperation among students. The findings of this study supported the second principle. Student collaboration in and outside of class, along with the help of the instructor contributed to student satisfaction in MME course. This collaboration was not unique to the MME course, as students in the lecture section collaborated with each other as well. The main difference was that this collaboration happened solely outside of class for the students in the lecture section, whereas students in the MME section worked together during class time on the assignments.

Another factor that may have contributed to the outcome of the study was the access to supplementary videos. Students in both course sections were able to view the YouTube videos provided by a faculty member in the department. Access to these videos was important to students in both the MME and lecture sections, according to the student interviews. Because many of these videos were also embedded into the MML software, and could also be accessed via YouTube, students in the lecture section had the benefit of having some of the multimedia content that was available to the students in the MME section. This finding is supported by the third and seventh Principles of Good Practice, which are to encourage active learning and to respect diverse talents and ways of learning (Chickering & Gamson, 1987). Active learning techniques can be hands-on, experiential, participative, or inquiry-based (Sorensen & Baylen, 2009), and the technology provided students with animations, graphing technologies, and videos. The instructors of both conditions provided diverse ways of learning through visuals, videos, and collaboration.

Another facilitator to the students learning was practice opportunities. Students in the lecture-based course (50%) and students in the MME course (25%) reported that opportunity for practice was a facilitator to learning the mathematics. Steele (2010), listed repetition and practice as important strategies for high school students with learning disabilities (LD). According to Steele (2002), guided and independent practice is effective in improving mathematics performance of individuals who have LD, and Biggs (1994) stated that, “understanding grows with repetition” (p. 27).

Another finding from the interviews and the course survey that was supported by the literature was that students in the MME course were content to be in the MME course; students in the lecture course were content to be in the lecture course. The student satisfaction survey showed no difference in the level of satisfaction between the MME course and the lecture-based course. As mentioned previously in this chapter, Taylor (2008) reported that for some students, the lecture method was best, and for other students the computer-based instruction was best. According to “Dr. Bunch”, students who take a course in the MME section and do well want to continue in the MME section for the rest of their sequence of courses, and likewise for the students who start in the lecture section.

The MME course seemed to be good for the students who progress through the material or learn slower than average, as well as for the students who progressed faster than the average. One student finished the MME course in three weeks and made a 95 on the final exam. This student would have had to go at a slower pace if he had been enrolled in the lecture section.

PAST EXPERIENCES OF STUDENTS AND STUDENTS’ DISPOSITIONS

Students had bad experiences with teachers in the past, and yet all students reported having a helpful instructor and made positive comments about the instructors in both the lecture-based and MME course. Even though the students discussed their difficulties with mathematics, they were able to identify the factors that helped them in the present course. Although the students discussed their negative feelings towards learning mathematics, they expressed positive feelings concerning the facilitators present in both conditions. Students from both sections were able to benefit from having a helpful instructor who provided one-on-one instruction, collaboration with peers, supplementary videos, and practice opportunities.

LIMITATIONS

There were several limitations to this study. The first limitation was that groups could not be randomly assigned. Students self-selected either the MME course or the lecture course. Some students did not know when they signed up what type of class they had selected but were able to switch once they received their assignment. No students switched course sections after classes began, and in both sections, those who were interviewed reported satisfaction with the type of course in which they had enrolled.

A second limitation was student attrition. Because there were three students who dropped out of the MME course and two students who dropped out of the lecture course, final exam, posttest, and survey data could not be collected for five of the students. Because one student finished the MME course early, posttest and survey data could not be gathered from that student.

The third and limitation was a lack of survey data. Only three students in the MME section completed the post-course survey. Follow-up emails were sent to the remaining students in the course who did not complete the surveys, but no responses were received.

The fourth limitation was that the study was conducted in the summer. Students did complain that the session was too short in both the MME as well as the lecture section. Because the summer session is shorter than a spring or fall session, the students are able to concentrate on only one class for a shorter period of time. However, because this was a new class that had just started in the spring, it was not possible to get longitudinal data to determine whether students did better during the longer or shorter sessions.

Finally, in coding the interview transcripts for this study, the interrater reliability (IRR) was low. It was difficult to achieve a high IRR with the two independent researchers. Armstrong, Gosling, Weinmen and Marteau (2014) attempted to explain the difficulty in achieving high IRR in a qualitative study as they described analysis as "a form of interpretation and interpretation involves a dialogue between researcher and data in which the researcher's own views have important effects" (p. 605). The authors further stated that, "this inherent subjectivity is freely acknowledged in qualitative research, indeed it is often cited as a hallmark of this approach" (p. 605). However, the concept of reliability was used to verify the codes attached to participants' statements, and as a means to ensure rigor. Therefore, the low IRR was considered a limitation of this study.

FUTURE RESEARCH

This study compared an eight-week lecture section to a five-week MME section of introductory algebra. Future research should include a replication of this study to compare courses taught for the same length of time. Because there were no statistically significant differences in the two modes of instruction, courses should continue to be taught using multimedia-enhanced instruction as well as lecture-based instruction, especially because student preferences suggest both modes are satisfactory. The findings obtained from this study cannot be generalized to other instructional settings, because of the low number of students. A similar study to this one should be replicated at other community colleges to further realize the outcomes of multimedia-enhanced instruction on students' achievement of basic algebra.

Future studies should also be conducted to investigate the interactions between instructors and students. One of the findings of this study was that students perceived having a helpful instructor as a facilitator to their learning the mathematics. Interviews should be conducted to determine how the instructors perceive their interactions with the students. Students should also be interviewed in more depth to determine how they perceive their interactions with the instructors, and what attributes define a "helpful instructor."

Students from different linguistic backgrounds may have difficulty understanding mathematical concepts. Students may also have issues concerning the vocabulary of algebra. Future research should be conducted to address the discourse of mathematics between the instructors and students from different linguistic backgrounds. Researchers should observe the interactions between instructors and students to discover whether students from different linguistic backgrounds are inhibited in their communication with the instructor. Further evidence should be collected through interviews with the students.

EDUCATIONAL IMPLICATIONS

There are several educational implications for the design and delivery of future MME and lecture-based developmental mathematics courses. Student contact with the course instructor and one-on-one instruction should be provided. All of the students in both course sections reported this as a facilitator of their learning the mathematics. The second educational implication from this study is the importance of providing students with the opportunities for collaboration with peers. All students who were interviewed in both course sections benefited from the collaboration with their peers to help each other learn the mathematics curriculum. The third educational implication is the significance of providing multiple ways of learning the course material including videos, graphics, and animations to support the diverse needs of the learners. All of the students who were interviewed in both sections of the course described the importance of the supplementary videos provided by the instructor of the lecture-based section. Providing students with multiple ways to access the course material supports the needs of diverse learners (Sorensen & Baylen, 2009). All of these components of the learning environment (student-faculty contact, collaboration with peers, and multiple ways to access the course material) interact with each other to construct the type of experience fundamental to student learning (Simonson et al., 2015).

APPENDICES

Appendix A: IRB Approval Letter

OFFICE OF RESEARCH SUPPORT

THE UNIVERSITY OF TEXAS AT AUSTIN

P.O. Box 7426, Austin, Texas 78713 · Mail Code A3200
(512) 471-8871 · FAX (512) 471-8873

FWA # 00002030

Date: 05/18/15

PI: Diane P Bryant

Dept: Special Education

Title: A Multimedia-Enhanced Developmental Mathematics Course

Re: IRB Exempt Determination for Protocol Number 2014-10-0018

Dear Diane P Bryant:

Recognition of Exempt status based on 45 CFR 46.101(b)(2).

Qualifying Period: 05/18/2015 to 05/17/2018. *Expires 12 a.m. [midnight] of this date.*
A continuing review report must be submitted in three years if the research is ongoing.

Responsibilities of the Principal Investigator:

Research that is determined to be Exempt from Institutional Review Board (IRB) review is not exempt from ensuring protection of human subjects. The Principal Investigator (PI) is responsible for the following throughout the conduct of the research study:

1. Assuring that all investigators and co-principal investigators are trained in the ethical principles, relevant federal regulations, and institutional policies governing human subject research.
2. Disclosing to the subjects that the activities involve research and that participation is voluntary during the informed consent process.
3. Providing subjects with pertinent information (e.g., risks and benefits, contact information for investigators and ORS) and ensuring that human subjects will voluntarily consent to participate in the research when appropriate (e.g., surveys, interviews).
4. Assuring the subjects will be selected equitably, so that the risks and benefits of the research are justly distributed.
5. Assuring that the IRB will be immediately informed of any information or unanticipated problems that may increase the risk to the subjects and cause the category of review to be reclassified to expedited or full board review.

6. Assuring that the IRB will be immediately informed of any complaints from subjects regarding their risks and benefits.

7. Assuring that the privacy of the subjects and the confidentiality of the research data will be maintained appropriately to ensure minimal risks to subjects.

8. Reporting, by submission of an amendment request, any changes in the research study that alter the level of risk to subjects.

These criteria are specified in the PI Assurance Statement that was signed before determination of exempt status was granted. The PI's signature acknowledges that they understand and accept these conditions. Refer to the Office of Research Support (ORS) website www.utexas.edu/irb for specific information on training, voluntary informed consent, privacy, and how to notify the IRB of unanticipated problems.

1. Closure: Upon completion of the research study, a Closure Report must be submitted to the ORS.

2. Unanticipated Problems: Any unanticipated problems or complaints must be reported to the IRB/ORS immediately. Further information concerning unanticipated problems can be found in the IRB Policies and Procedure Manual.

3. Continuing Review: A Continuing Review Report must be submitted if the study will continue beyond the three year qualifying period.

4. Amendments: Modifications that affect the exempt category or the criteria for exempt determination must be submitted as an amendment. Investigators are strongly encouraged to contact the IRB Program Coordinator(s) to describe any changes prior to submitting an amendment. The IRB Program Coordinator(s) can help investigators determine if a formal amendment is necessary or if the modification does not require a formal amendment process.

If you have any questions contact the ORS by phone at (512) 471-8871 or via e-mail at orsc@uts.cc.utexas.edu.

Sincerely,

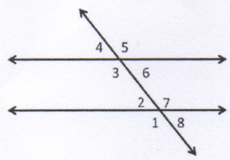
James P. Wilson

James Wilson, Ph.D.
Institutional Review Board Chair

Appendix B: Pretest/Posttest

Math 0308 PRETEST **(PLEASE DO NOT WRITE ON THIS PAPER)**

1) If $p \| q$ and $m < 8 = 40^0$, what are the measures of the other angles?



A) $m<2 = m<4 = m<6 = 40^0$, $m<1 = m<3 = m<5 = m<7 = 50^0$

B) $m<5 = m<6 = m<7 = 40^0$, $m<1 = m<2 = m<3 = m<4 = 140^0$

C) $m<2 = m<4 = m<6 = 40^0$, $m<1 = m<3 = m<5 = m<7 = 150^0$

D) $m<2 = m<4 = m<6 = 40^0$, $m<1 = m<3 = m<5 = m<7 = 140^0$

2) Solve $x = \dfrac{w+y+z}{7}$ for y

A) $y = 7x - 7w - 7z$ B) $y = 7x + w + z$ C) $y = x - w - z - 7$ D) $y = 7x - w - z$

3) Solve $8z + 7 \geq 9z + 3$

A) $\{z|z > 8\}$ B) $\{z|z \leq 8\}$ C) $\{z|z \leq 4\}$ D) $\{z|z \geq -4\}$

4) Subtract $(9n + 9n^5 - 10n^4) - (15n^4 + 3n^5 - 10n)$

A) $6n^5 - 25n^4 + 19n$ B) $-7n^{10}$ C) $6n^5 - 7n^4 - 8n$ D) $6n^5 - 25n^4 - 8n$

5) Factor Completely $x^2 - 4x - 12$

A) $(x + 2)(x - 6)$ B) $(x - 2)(x + 6)$ C) $(x - 2)(x + 1)$ D) Prime

6) The sum of three consecutive integers is 318. Find the largest integer.

A) 108 B) 107 C) 105 D) 106

7) Find the length of a rectangular lot with a perimeter of 116 meters if the length is 8 meters more than the width.

(P = 2L + 2W) A) 33 m B) 66 m C) 25 m D) 58 m

8) Perform the indicated operation. Write the answer in scientific notation. $(2 \times 10^7)(7 \times 10^6)$

A) 1.4×10^{14} B) 1.4×10^{13} C) 14×10^{14} D) 14×10^{42}

9) Multiple and Simplify $5^{10} \cdot 5^{-3}$

A) 5^3 B) 5^{10} C) 5^4 D) 5^7

10) Factor by grouping. $x^3 + 2x^2 + 5x + 10$

A) $(x - 2)(x^3 + 5)$ B) $(x + 2)(x^2 - 5)$ C) $(x + 2x)(x^2 + 5)$ D) $(x + 2)(x^2 + 5)$

11) Find the product $(11p + 5)(11p - 5)$

A) $p^2 - 25$ B) $121p^2 - 25$ C) $121p^2 - 110p - 25$ D) $121p^2 + 110p - 25$

12) Simplify $\left(\frac{x^3y}{z^4}\right)^3$

A) $\frac{x^9y^3}{z^{12}}$ B) $\frac{x^3y^9}{z^{12}}$ C) $\frac{x^9y^3}{z^4}$ D) $\frac{x^6y^3}{z^7}$

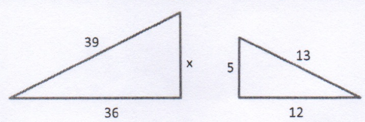
13) $15 + 5^2(27) - (-11)$

A) 1091 B) 701 C) 58 D) 124

14) Find the x- and y- intercepts of the equation: $y = 3x + 6$

A) (-2, 0), (0, 6) B) (2, 0), (0, 6) C) (-2, 0), (0, -6) D) (2, 0), (0, -6)

15) Assume that the given triangles are similar. Provide the missing length.



A) 20 B) 5 C) 9 D) 15

16) Multiply. $(w - 14)^2$

A) $w^2 + 196$ B) $w^2 - 28w + 196$ C) $w^2 + 28w + 196$ D) $2w + 196$

17) Collect like terms $3p^2 - 9 - 6p + 8p^2 - 9p$

A) $3p^2 - 15p - 17$ B) $11p^2 - 15p - 9$ C) $11p^2 + 15p + 9$ D) $11p^2 - 6p - 9$

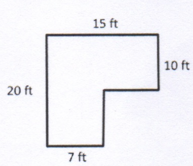
18) Solve the equation. $-8b + 8 + 6b = -3b + 13$

A) 5 B) 13 C) -8 D) -13

19) Divide $\frac{35x^3 - 45x^2 - 20x}{5x}$

A) $35x^2 - 45x - 20$ B) $7x^2 - 9x - 4$ C) $7x^3 - 9x^2 - 4x$ D) $7x^3 - 45x^2 - 20x$

20) Find the area.



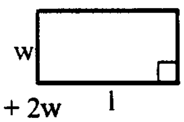
A) 220 ft^2 B) 270 ft^2 C) 200 ft^2 D) 230 ft^2

Appendix C: Final Exam

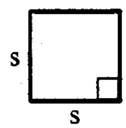
Houston Community College

PLANE GEOMETRY

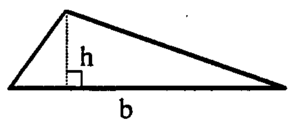
Rectangle
Area: $A = lw$
Perimeter: $P = 2l + 2w$



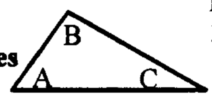
Square
Area: $A = s^2$
Perimeter: $P = 4s$



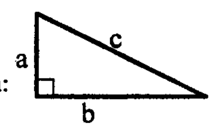
Triangle
Area:
$A = \frac{b \bullet h}{2}$



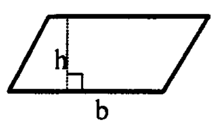
Sum of Angle Measures
$A + B + C = 180°$



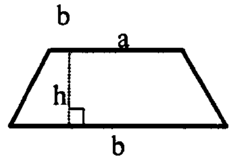
Right Triangle
Pythagorean Theorem:
$a^2 + b^2 = c^2$



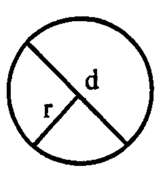
Parallelogram
Area: $A = bh$



Trapezoid
Area: $A = {}^{1}/_{2}h(a+b)$



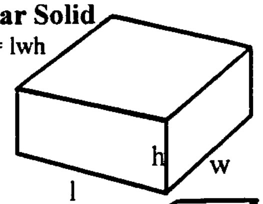
Circle
Area: $A = \pi r^2$
Circumference:
$C = \pi d$ or $C = 2\pi r$
$\pi = {}^{22}/_{7}$ or $\pi = 3.14$



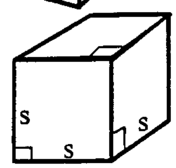
$$\frac{\text{arc length}}{\text{circumference}} = \frac{\textit{angle}}{360^{\circ}}$$

SOLID GEOMETRY

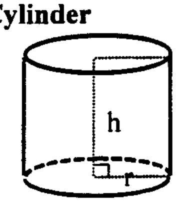
Rectangular Solid
Volume: $V = lwh$



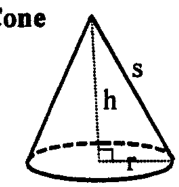
Cube
Volume: $V = s^3$



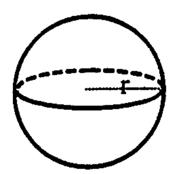
Right Circular Cylinder
Volume: $V = \pi r^2 h$



Right Circular Cone
Volume: $V = {}^{1}/_{3}\pi r^2 h$



Sphere
Volume:
$V = {}^{4}/_{3}\pi r^3$



HOUSTON COMMUNITY COLLEGE SYSTEM
Math 0409 Final Exam Version A

Please bubble-in the letter on your Scantron Form that corresponds to the best answer for each of the following 33 multiple choice questions. Problems from this examination are not to be omitted. Please show all work and pertinent calculations on your separate examination worksheets. Return all worksheets to your instructor.
PLEASE DO NOT WRITE ON THESE EXAMINATION PAPERS.

1) Find the product. $(7a + 11c)(7a - 11c)$

A) $49a^2 - 154ac - 121c^2$
B) $7a^2 - 11c^2$
C) $49a^2 - 121c^2$
D) $49a^2 + 154ac - 121c^2$

2) Decide whether or not the ordered pair is a solution to the equation:
$3x - 2y = 14$; $(2, 4)$
A) No
B) Yes

3) Evaluate the polynomial: $2x^2y - xz^3$ for $x = -3$, $y = 2$, and $z = 3$

A) 36
B) -45
C) 117
D) 153

4) Perform the indicated operation. Write the answer in scientific notation: $\dfrac{6 \times 10^9}{2 \times 10^{-5}}$

A) 3×10^{14}
B) 6×10^{14}
C) 6×10^4
D) 3×10^4

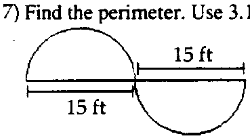
5) Solve the equation: $\frac{1}{4}(12x - 20) = \frac{1}{5}(25x - 15)$

A) $\frac{1}{8}$
B) -8
C) -1
D) 1

6) Find the number for which the rational expression is not defined. $\dfrac{b - 8}{8b - 32}$

A) 0
B) 7
C) 8
D) 4

7) Find the perimeter. Use 3.14 for π.



A) 77.1 ft B) 124.2 ft C) 47.1 ft D) 94.2 ft

8) Simplify: $6 \cdot 10 - (15 - 12) \div 3 - (9 - 8)$

A) 58 B) 10 C) 42 D) 18

9) Subtract: $(-7x^4 + 4x^6 + 8 + 3x^5) - (-1 - 8x^5 + 6x^6 + 3x^4)$

A) $-2x^6 + 11x^5 - 10x^4 + 9$ B) $-2x^6 - 5x^5 - 4x^4 + 7$

C) $10x^6 - 5x^5 - 4x^4 + 9$ D) $10x^6 - 5x^5 - 4x^4 + 7$

10) Convert to decimal notation: 6.37×10^{-4}

A) 0.00637 B) 0.0000637 C) 0.000637 D) -637,000

11) Multiply: $(7a - 5)^2$

A) $7a^2 + 25$ B) $49a^2 + 25$ C) $49a^2 - 70a + 25$ D) $7a^2 - 70a + 25$

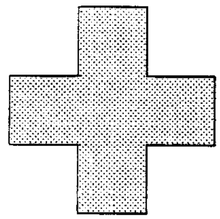
12) Solve the equation: $\frac{2}{5}x - \frac{1}{3} = 4$

A) $\frac{12}{5}$ B) $\frac{65}{6}$ C) 15 D) -15

13) Multiply and simplify: $3^{-4} \times 3^7$

A) 3^7 B) 3^3 C) 9^3 D) 9^{-28}

14) Find the area of the shaded region.



Each side 10 ft

A) 400 ft^2 B) 120 ft^2 C) 500 ft^2 D) 300 ft^2

15) Collect like terms and write in descending order: $z^3 - 3z^4 + 5z^2 - z^4 + 6z^3$

A) $-4z^4 + 7z^3 + 5z^2$
B) $4z^4 - 7z^3 - 5z^2$
C) $-3z^4 + z^3 + 5z^2$
D) $-4z^8 + 7z^6 + 5z^2$

16) Solve $x = \frac{w + y + z}{8}$ for the variable y.

A) $y = 8x + w + z$
B) $y = 8x - w - z$
C) $y = x - w - z - 8$
D) $y = 8x - 8w - 8z$

17) Divide: $\frac{12x^7 + 14x^2 - 8x}{2x}$

A) $6x^6 + 7x - 4$ B) $6x^7 + 7x^2 - 4x$ C) $12x^6 + 14x - 8$ D) $6x^7 + 14x^2 - 8x$

18) Multiply and simplify the result: $\frac{k^2 + 8k + 12}{k^2 + 15k + 54} \cdot \frac{k^2 + 9k}{k^2 + 4k + 4}$

A) $\frac{k}{k^2 + 15k + 54}$ B) $\frac{1}{k+2}$ C) $\frac{k^2 + 9k}{k+2}$ D) $\frac{k}{k+2}$

19) Solve the equation: $-10.1q + 1.7 = -59.2 - 1.4q$
A) -70 B) 6.2 C) 7 D) 6.0

20) Translate the phrase to an algebraic expression:
Twice the sum of a number and six
A) 2(x + 6) B) 6x + 2 C) 2x + 6 D) 2x - 6

21) Which of the following is a factor of $3x^2 + 6x - xy - 2y$?

A) $(x - 2)$ B) $(2x - y)$ C) $(3x - y)$ D) $(3x + y)$

22) Find the solution set of the inequality: $-5x > 35$

A) $\{x| x > 7\}$ B) $\{x| x < 7\}$ C) $\{x| x > -7\}$ D) $\{x| x < -7\}$

23) A tree casts a shadow 27 m long. At the same time, the shadow cast by a 66 m tall statue is 56 m long. Find the height of the tree to the nearest tenth of a meter.

A) 22.9 m B) 31.8 m C) 21.4 m D) 30.3 m

24) Which of the following is a factor of $x^2 - 4x - 21$?

A) $x - 8$ B) $(x + 1)$ C) $(x + 3)$ D) $(x + 7)$

25) Find the solution set of the inequality: $35x + 15 > 5(6x + 9)$

A) $\{x| x > 6\}$ B) $\{x| x \geq 6\}$ C) $\{x| x < 6\}$ D) $\{x| x \leq 6\}$

26) Multiply: $(3m + 7)^2$

A) $3m^2 + 49$ B) $3m^2 + 42m + 49$

C) $9m^2 + 42m + 49$ D) $9m^2 + 49$

27) Find the length of a rectangular lot with a perimeter of 54 meters if the length is 13 meters more than the width. ($P = 2L + 2W$).

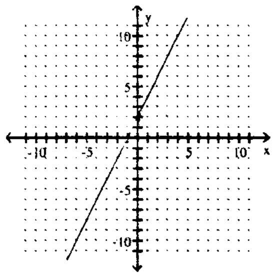
A) 64 m B) 15 m C) 18 m D) 20 m

28) Multiply: $(2p - 1)(4p^2 + 2p + 1)$

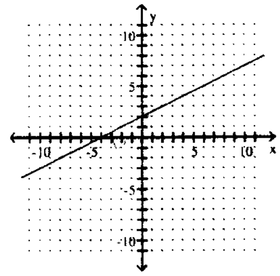
A) $4p^3 - 1$ B) $8p^3 + 6p^2 - 1$ C) $8p^3 - 1$ D) $8p^3 + 1$

29) Graph the linear equation: $y = 2x + 2$

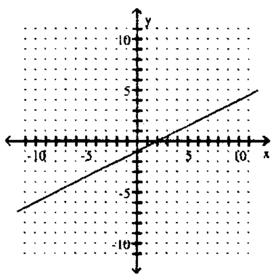
A)



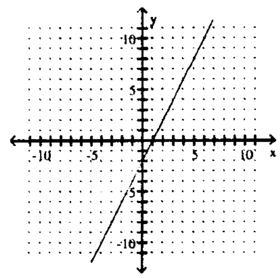
B)



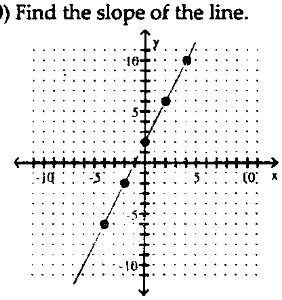
C)



D)



30) Find the slope of the line.



A) -2 B) 2 C) $\frac{1}{2}$ D) $-\frac{1}{2}$

31) Select the equation of the line with the slope of $m = -\frac{4}{3}$ and y-intercept (0, 8).

A) $y = \frac{4}{3}x - 8$ B) $y = \frac{4}{3}x + 8$ C) $y = -\frac{4}{3}x - 8$ D) $y = -\frac{4}{3}x + 8$

32) Factor completely: $49x^2 - 36$

A) Prime
B) $(7x + 6)^2$
C) $(7x + 6)(7x - 6)$
D) $(7x - 6)^2$

33) Find the intersection: $\{0, 5, 8\} \cap \{4, 6, 8, 10\}$

A) {5, 8}
B) {8}
C) {0, 5, 4, 6, 8, 10}
D) {0, 5}

Appendix D: Questionnaire

1. What is your age:

a. Under 20	b. 36 – 40
c. 20 – 25	d. 41 – 45
e. 26 – 30	f. 46 – 50
g. 31 – 35	h. 51 +

2. Gender:

a. Male	b. Female

3. Race/ethnicity

a. American Indian or Alaskan Native	d. Asian or Pacific Islander
b. African American	e. Hispanic
c. White/Caucasian	f. Other: ___________________

4. What is your student status?

    a. Full time student (taking 4 or more classes)

    b. Part time student (taking 1-3 classes)

5. Are you currently working?

    a. Yes

       If yes, how many hours per week? _______ hours per week

    b. No

6. When you registered for this math class, did you know whether it was a lecture class or a computer math class?
    a. Yes, I knew this math class was a lecture class
    b. Yes, I knew this math class was a computer math class
    c. No, I did not know if the class was a lecture or computer math class

7. Have you previously taken this course?
    a. If yes, then how many times in a lab?
    b. If yes, then how many times in a lecture?

8. Have you been diagnosed with a disability(ies)? Yes/no
    a. If yes, which disability(ies)?
    b. When were you diagnosed (age or year)?

9. Is English the primary language spoken in your home? Yes/no
    c. If no, what is your primary language?
    d. Did you attend bilingual classes in elementary school? If yes, which grades?
    e. Did you attend bilingual classes in middle and high school? If yes, which grades?

10. Since high school, have you taken a developmental math course? Yes/no

11. On a scale of 1 – 5, how do you feel about math?

1	2	3	4	5
I love it	I like it	It's okay	I don't like it	I hate it

Appendix E: Course Survey

Summer 2015 Math 0409 Course Evaluation Survey

	5 Strongly Agree	4 Agree	3 Neither agree nor disagree	2 Disagree	1 Strongly Disagree
The course presented skills in a helpful sequence					
The course provided an appropriate balance between instruction and practice					
The course was appropriate for the stated level of the class					
The course was organized in a way that helped me learn					
The course provided a mixture of explanation and practice					
The course was effectively organized					
The course assignments and lectures usefully complemented each other					
The course instructions (including, manuals, handouts, etc.) were clear					
The course work helped me understand concepts more clearly					
Instructions for course materials (including manuals, handouts, etc.) were clear					

Appendix F: Fidelity Checklists

FIDELITY OF TREATMENT AND CONTROL CONDITIONS: SUMMER 2015

Date:		**Time:**
Condition:	__Treatment	__Control

Items	Present? +/-	Comments
Lecture		
Small group		
Technology		
Opportunities for practice		
One-on-one instruction		
Monitoring progress		

FIDELITY OF TREATMENT CONDITION: SUMMER 2015

Date:	**Time:**

Items	Present? +/-	Comments
Instructor checks individual student progress on teacher computer		
Instructor walks up and down through the lab, asking each student what they need help with.		
Instructor gives one-on-one help in the back of the classroom		
Instructor works with the student at their computer		
Instructor teaches to the whole class problems missed on most recent unit test		
Instructor reviews the final exam problems and works problems in front of whole class		

Appendix G: Semi-structured Interview Form

A. In-class general technology

How does the lab and technology help your in-class learning?
How does the lab and technology create barriers for your in-class learning? What can you recommend to the instructor to reduce barriers?

What do you like about the lab setup?
What do you not like about the lab setup?
What do you like about the software?
What do you not like about the software?
What helps with your learning the math?
What hinders you learning the math?

B. Past experiences with K-12 math instruction:

1. Tell me about your experiences with your previous math courses? How did you feel about taking these courses? Are you willing to share your grades with me?

What do you like about math?
What do you not like about math?
And/or:
Tell me about a positive experience you have had with math in school.
Tell me about a negative experience you have had with math in school.

C. If a student has LD (as indicated on the questionnaire)
How did the teacher's instruction in your previous math classes help or hinder your understanding of the math being taught?
What needs to be done instructionally to help you learn the math being taught?

What accommodations did you get in high school?
What are you getting now? Have you asked for accommodations?
What accommodations do you think you need in this course? Why do you need these accommodations? What do you know about the course that makes you think you need these accommodations?
How does the technology used in this course provide you with accommodations that you don't have to ask for?
How does technology help you compensate for your math disability (assuming they have a math disability-what is they don't and they do have a disability in reading)?

D. Participants' use of technology:

How do you use technology to help you in your schoolwork?

What technology do you use personally?

If they have a negative response regarding technology, probe further. Did you try to enroll in the non-lab section of this course?

If they have a positive response regarding technology, probe further. Did you intentionally enroll in the lab section of this course? If so, why?

E. In-class interactions

How would you describe to someone how learning occurs in this class?

How do you interact with the other students in the class?

How do you interact with the teacher? Do you ever email or chat with the teacher?

How does the in-class interaction facilitate your learning?

F. Outside of class

How does the lab and technology help your outside of class learning?

How does the lab and technology create barriers for your outside of learning? What can you recommend to the instructor to reduce barriers?

How do you work on the course material when not in the lab?

Do you get help from other students? How do you help each other?

Do you like working in the lab or at home?

Do you have access to the printers?

How much of the material do you print out?

The last two questions give insight into how students access the material – whether by print or on screen. Is the technology a barrier? Would they rather have paper?

Appendix H: Dates of Observation

MML	Lecture
June 8, 10:30 am *	June 8, 8 am *
June 8, 5:30 pm *	
June 22, 5:30 pm	
June 23, 10:30 am	
June 23, 5:30 pm	June 23, 8 am
	June 24, 8 am
July 1, 5:30 pm	
July 2, 10:30 am	July 2, 8 am
July 7, 5:30 pm	
July 8, 5:30 pm	July 8, 8 am
MML section ended	July 22, 8 am
	July 29, 8 am

* Did not collect fidelity on June 8, the first day of class

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